ग्रीन हाउस से काटे गए गुलाब के फूलदान जीवन तथा गुणवत्ता पर अध्ययन

STUDIES ON VASE LIFE AND QUALITY OF GREENHOUSE CUT ROSES

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STUDIES ON VASE LIFE AND QUALITY OF GREENHOUSE CUT ROSES

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This is to certify that the thesis entitled, **"Studies on vase life and quality of greenhouse cut roses"** submitted to the Faculty of Post Graduate School, Indian Agricultural Research Institute, New Delhi by **Mr. Vinod Kumar** in partial fulfillment of the requirements for the award of the degree of **Doctor of Philosophy** in **Horticulture**, is a record of *bona-fide* research work carried out by him under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of investigation have been duly acknowledged.

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To my beloved parents and all those Agricultural Scientists who are striving hard to bring smile on the face of starving millions

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

1. INTRODUCTION

Postharvest life and quality of cut flowers play crucial role in determining the success in both domestic as well as in export market. Flowers are highly perishable and prone to postharvest losses and hence, have to be handled with utmost care. Several parameters are used for evaluation of cut flowers by the researchers, commercial growers, florists, and amateurs. Among these parameters, keeping quality (synonymous-vase life, useful life, postharvest life, longevity, shelf life, display life and lasting quality) of harvested flowers is considered as the most important parameter. Keeping quality represents the potential useful life of flower in holding solution. Even amongst the cultivars of same species, wide differences in postharvest behaviour are observed (Halevy and Mayak, 1974). Certain flowers are inherently short-lived after harvest and pose unique problems in handling and marketing (Salunkhe *et al.*, 1990). A fresh flower is still a living specimen even though it has been severed from the plant. Its maximum potential vase life, although acceptable in the market place is short. There are many impinging forces that can interact to reduce fresh flower vase life. Although, 70 per cent of the potential lasting quality of cut flowers is pre-determined at harvest, postharvest factors influence remaining 30 per cent of the effects. All along the marketing channel of cut flowers, losses up to 50 per cent of the farm value could occur (Bhattacharjee, 1999a). To avoid such losses, postharvest management of flowers assumes considerable importance so as to deliver the flowers in garden-fresh condition to the consumers.

Flowers undergo rapid deterioration owing to their perishable nature. Storage of flowers is essential in order to slow down the physiological and biochemical changes, which have bearing on postharvest life and quality of flowers. Research on flower storage has increased in conjunction with rapid expansion of floriculture industry, however, in India, the research in this area is in its infancy. The greatest difficulty encountered in research related to flower storage derives from the great number of flower species and cultivars, short life span and delicacy of the product (Rudnicki *et al.*, 1986; Goszezynska and Rudnicki, 1988).

Different types of storage methods like controlled atmosphere (CA) and low-pressure (LP) had been attempted. Controlled atmosphere and low-pressure storage have not been commercially practiced due to lack of practicability. Low-pressure storage is considered best for maintaining the quality of flowers by retarding physiological and biochemical deterioration.

Cut roses often have a short vase life. Over a few days after harvest, petal discoloration, tissue browning, neck bending, loss of flower parts and total senescence usually occur. These events significantly compromise their commercial value. To overcome these deleterious effects, storage of cut roses is usually done at low temperature. Although the prolonged use of this technique is restricted by vascular blockage and loss of flower quality (Faragher *et al.*, 1984). Low temperature storage is of two types (i) wet cold storage, and (ii) dry cold storage. In wet cold storage, flowers are stored with their bases dipped in water or preservative solution. Wet cold storage is used to hold the flowers for short duration. Dry cold storage methods are usually used for long periods of storage. Usually during dry cold storage, flowers are packed in airtight bags or boxes. In wet cold storage, at 4^{0}C, the cut roses can be stored up to five days and at 8^{0}C, for two days, depending upon the varieties without affecting their ultimate quality in vase at ambient temperature (Palanikumar and Bhattacharjee, 2001).

Cut flower longevity depends on carbohydrate reserves of flowers, osmotic concentration and pressure potential of petal cells, stomatal functioning, differences in number of thick-walled supporting cells in the xylem element and phloem fibre and presence or absence of a complete ring of secondary thickening in flower peduncles, differences in the diffusive resistance of leaves in the field, lignification, level of plant hormones, and susceptibility to diseases and insects (Halevy and Mayak, 1979). Significant differences in postharvest life and intrinsic quality of cut flowers were recorded at IARI, New Delhi, among 10 rose cultivars and it was observed that 'Raja Surendra Singh of Nalagarh' had the longest vase life (10.6 days) and other cultivars in the order were 'Dr. B.P. Pal' (9.8 days), 'Arjun' (7.8 days), and 'Sonia Meilland' (7.4 days) (Bhattacharjee, 1993). De (1995) evaluated the vase life of 32 cultivars of cut roses and concluded that the cv. Anjelique expressed the longest vase life (12.2 days) while cv. Preyasi the shortest (5.3 days). However, flower diameter varied among the cultivars.

Treatment of flowers prior to cold storage with chemicals (known as 'pulsing') prevents vascular infections and inhibits ethylene production, replenishes the carbohydrate losses, or in some cases retards metabolic activities, which ultimately results in a prolonged storage period and high quality flowers with increased vase life after storage (Halevy and Mayak, 1974, 1981; Rudnicki *et al.*, 1981; Paulin, 1986; Vidhya Sankar and Bhattacharjee, 2002). In 'Super Star' roses pulsing with sucrose (3 per cent) for 18 hours at 20^0C, significantly prolonged the vase life, accelerated flower diameter, improved water uptake and also increased fresh and dry weight of the cut flower appreciably over the untreated cut flowers (Bhattacharjee, 1999). Experimental evidences on influence of pulsing and storage on biochemical and physiological changes on cut roses are meagre.

In agriculture, one of the potential uses of atomic radiation, particularly of gamma rays, is in the preservation of food products such as fruits, vegetables, mushrooms, cereals, pulses, spices, etc. by preventing senescence, insect infestation and microbial contamination. However, information on gamma irradiation of cut flowers to increase the postharvest life and quality is very scanty. Irradiation technology is practiced at quarantine stage in the imported cut flowers for insect disinfestation. But radiation damages not only the pests but also the host commodities. Tolerance to radiation varies with species to species and even variety to variety. So, determination of optimum dose of gamma irradiation is highly essential in the postharvest management of cut flowers. Moreover, the problem of unopening of buds can be overcome by radiation.

Biologically it is now accepted that DNA is the most critical target of radiation (Greez *et al.*, 1983). Other effects of radiation are on metabolic functions, bond breakage in proteins, depolymerization of starch (Grunewald, 1984) and ethylene production (Thomas, 1988). But, still physiological and biochemical changes occurring during the gamma irradiation have to be investigated in cut flowers to exploit this technology in postharvest management of cut flowers.

In the present study pulsing, cold storage, and optimum dose of gamma irradiation for enhancement of postharvest life and intrinsic quality of cut roses were studied in detail with the following objectives:

1. To study the effect of gamma irradiation and cold storage on vase life of greenhouse cut roses.
2. To standardize the period of dry and wet cold storage of cut roses.
3. To study the physiological and biochemical changes in cut rose treated with gamma irradiation and during storage.

2. REVIEW OF LITERATURE

Postharvest technology of cut flowers is an interesting and rewarding domain of investigation. Apart from other aspects in postharvest handling of cut flowers, pulsing and storage are of considerable importance. Recently irradiation technology is employed to kill or sterilize plant pathogens in the imported cut flowers at quarantine stage. Fresh cut flowers may deteriorate due to one or more reasons. The reasons may be inability of stems to absorb water due to vascular blockage, excessive water loss from cut ends and injured portion of cut flower, restricted supply of carbohydrates to support respiration, pests and diseases, and high evolution of ethylene. In spite of these constraints the researchers' endeavour should be to extend the vase life and flower quality so as to assure consumers' confidence in fresh flowers. Although cut flower production is less as compared to demand, 50 per cent of the flowers are damaged during preharvest, harvest and postharvest stages (Salunkhe *et al.*, 1990). Postharvest handling of cut flowers has been subjected to intensive as well as extensive research and many reviews have been published (Aarts, 1957b; Coorts, 1973; Rogers, 1973; Halevy, 1976; Halevy and Mayak, 1979, 1981; Mayak and Halevy, 1980; Mayak, 1987; Goszezynska and Rudnicki, 1988; Borochov and Woodson, 1989; Zieslin, 1989; Nowak *et al.*, 1991; Van Doorn and De Witte, 1997; Bhat *et al.*, 1999; Bhattacharjee, 1999; De and Bhattacharjee, 2000 and 2006a). At the same time it is pertinent to mention here that evidences regarding pulsing in conjunction with storage and gamma irradiation on postharvest life of cut roses are meagre.

This chapter is an attempt to review the research work done so far regarding pulsing with sucrose, cold storage, and gamma irradiation. And the manifesting effect of these treatments are seen on respiration rate, total soluble sugars, and total free amino acid contents of flowers which have ultimate bearing on the vase life and intrinsic quality of cut flowers.

2.1 EFFECT OF SUCROSE AS PULSING AND HOLDING SOLUTION

Placing the cut ends of flower stems in solution containing sugar and germicides for a period ranging from several hours to as long as two days is known as pulsing. This treatment may be used by the growers, wholesalers, or retail florists in order to extend the flower's subsequent life in vase water. Generally, the treatment is performed under light intensity of 2000 lux at temperatures from 20^0 to 27^0C. This results in prolonged flower life in water, faster flower opening and better coloration of petals (Halevy and Mayak, 1979). Pulsing is especially beneficial to flowers destined for long periods of storage or long distance transportation.

Sucrose is most widely used ingredient in pulsing that maintains the pool of dry matter and respirable substrates in flower petals. Exogenous sucrose replaces the depleted endogenous carbohydrates utilized during the postharvest life of flowers. Sugar gets accumulated in flower tissues, increases their osmotic concentration and improves their ability to absorb water and maintains turgidity (Bhattacharjee, 2006). But percentage of sugar varies with species and cultivars. Rose tolerates only 1.5 to 2.0 per cent sucrose (Halevy *et al.*, 1978). Different chrysanthemum cultivars vary greatly in their response to sugar concentration, from 2 to 30 per cent (Kofranek and Halevy, 1972). For gladiolus and bird of paradise, there is no sucrose injury even up to 25 per cent (Halevy *et al.*, 1978a). The optimum sucrose concentration for carnation is 10 per cent (Kofranek, 1976) and for cyclamen it is 15 per cent (Halevy *et al.*, 1984).

Sucrose is the major translocating carbohydrate in carnation (Ho and Nichols, 1975), as in most other plants. However, unlike in many other tissues, in carnation petals sucrose and not starch seems to be the main storage carbohydrate (Dimalla and Van Staden, 1980). Acid invertase, which hydrolyses sucrose into its constituents glucose and fructose, is very active in the young flowers but its activity declines with age (Dimalla and Van Staden, 1980). The decline is mainly due to the accumulation of a specific inhibitor in the petals (Halaba and Rudnicki, 1983). The resulting concentration gradient may allow passive sucrose translocation (Cook and Van Staden, 1980). This may explain why young petals are a major sink for carbohydrates and accumulate reducing sugars in their vacuoles, but as the flower senesces sucrose is translocated out of the petals into the developing ovary, which then becomes the major sink (Nichols and Ho, 1975). Continuous supply of sucrose or glucose to the inflorescence of cut dahlias resulted in the accumulation of reducing sugars and sucrose in the flowers (Lukaszewska, 1983 and 1986).

Paulin (1986) reported that sugar supply prevents the enzymatic activities involved in the ethylene biosynthesis. Exogenous sugars delay senescence in many cut flowers. This may be taken as an argument for role of low sugar levels in activation of salvage pathway and in cell death. However, it is often not clear to what extent applied sugars serve to improve petal-water relations by increasing the level of osmotic solutes or delay cell death. Exogenous sugars also delay the time to visible senescence in petals where senescence is not regulated by ethylene, but the effect is generally much smaller than in species with ethylene-regulated petal senescence. In this case, the sugar effect is mainly due to a reduction of ethylene sensitivity. Addition of sucrose may antagonize the abscissic acid induced promotion of petal senescence (Borochov *et al.*, 1976). Thimann *et al.* (1977) hypothesized that sugar starvation is the direct cause of leaf senescence. Sucrose is effective in promoting the vase life of tuberose cut flowers (Pathak *et al.*, 1979). Kuiper *et al.* (1995) reported that an aqueous solution of sucrose (45 mM) induced proper flower bud opening in 'Madelon' cut rose. Singh (1995) studied that pulsing of cut 'Raktagandha' rose with sucrose (3 per cent) for 24 hours increased water uptake, gained fresh weight at senescence and improved flower quality. Bhattacharjee (1998, 1999) after an intensive examination on effects of pulse treatments consisting of different sugars and other chemicals in cut rose cv. Happiness concluded that D- fructose (3 per cent) was the best treatment. Ichimura (1998) investigated the effects of sucrose treatment on vase life of several cut flowers. Pulse treatment was effective in improving the vase life of cut flowers whereas continuous treatment had the additional advantage of increasing anthocyanins concentration in petals. Sivasamy (1998) reported increase in vase life of 'Raktagandha' cut rose when pulsed with sucrose (3 per cent) + 8-HQC (150 ppm) for 24 hours prior to wet cold storage at 3^0C. In 'Sonia' cut rose treatment with sucrose and 8-HQS, significantly improved vase life (Ichimura *et al.*, 1999). Jothi and Balakrishnamoorthy (1999) observed that pulsing of cut roses cv. Happiness at tight bud stage for 24 hours at 4^0 to 6^0C with sucrose (3 per cent) + $Al_2(SO_4)_3$ (300 ppm) + 8-HQC (200 ppm) resulted in increased water uptake, flower diameter and decreased percentage of petal wilting.

Oren *et al.* (2001) investigated changes in rose cv. Mercedes cut flowers during vase life to assess whether petal blueing prior to wilting is part of senescence process. Petal colour of flowers treated with sucrose (2 per cent) did not change at day 7 and showed a very slight lightening of their original orange to red-orange shade at day 14, while the petal colour of control flowers (water treated) changed from their original red-orange to red-purple at day 7, and to deep-purple (with deeper purple at the edges) at day 14. Petal water content in control flowers decreased at days 8 and 11, while that in sucrose treated flowers remained high until day 21. Cell sap pH increased dramatically in control flowers during initial 4 days of vase life. In sucrose treated flowers, the pH remained relatively constant during the first day of vase life and then moderately increased at day 6. An increase in the pH values of the anthocyanins caused the blueing of senescent rose petals.

Cut 'Serena' rose pulsed with sucrose (8 per cent) and 8-HQS (200 ppm) had longer vase life (14.28 days) than those pulsed with different concentrations of sucrose or placed in distilled water from the beginning of the experiment (Deambrogio and Garibaldi, 1991). Pulsing of China aster cut stems with sucrose (8 per cent) for 18 hours resulted in increased percentage of fully opened buds, number of buds per stem and lowest percentage of unopened buds rather than 4 per cent and 12 per cent sucrose (Shobha and Gowda, 1992). In Gladiolus cvs Hunting Song, and Spic & Span, pulsing with sucrose (5 per cent) + 8-HQC (200 ppm) alone and in combination after STS (4 mM) pulsing for 30 minutes + sucrose + 8-HQS extended the vase life by 1.5 to 1.6 times and improved flower quality significantly by increasing number of opened florets, floret diameter, fresh weight and solution uptake (Song *et al.*, 1992). Pulsing of cut flowers of *Chrysanthemum leucanthemum* with 2, 4, 6, 8 or 10 per cent sucrose increased vase life from 14.9 days in control to 19.07, 23.25, 27.42, 31.60, and 35.80 days, respectively (Moraes *et al.*, 1997). Yan *et al.* (1997) observed that in cut rose (*Rosa rugosa*) stems treated with combination of sucrose (3 per cent) and other preservatives increased vase life over control flowers.

Bhattacharjee and Palanikumar (2001) reported that pulsing with sucrose (3 per cent) + $Ca(NO_3)_2$ (0.5 per cent) has been best treatment in respect of vase life in 'Raktagandha' cut rose followed by sucrose (3 per cent) + $Al_2(SO_4)_3$ (300 ppm). Lee and Xue (2001) suggested that sucrose was best preservative since water content increased and the degradability of soluble protein decreased in cut rose cv. Samantha flowers. Hence, senescence duration of the cut flower was postponed. Meng (2001) investigated the effects of ABA on sugar concentrations in leaves and petals of cut rose cv. Mercedes. Sugar supplies energy to cut flowers and gives them a longer vase life. However, if too much sugar is added, necrotic spots on leaves and black necks develop and quality of flowers decreases. ABA induces closure of leaf stomata, decreases movement of sugars to leaves in the transpiration steam, and prolongs the life of cut flowers.

Singh *et al.* (2001) reported significant increase in vase life of 'Super Star' cut rose pulsed with sucrose (3 per cent) for 18 hours at 20^0C. Bhaskar *et al.* (2002) emphasized that electrolyte leakage and peduncle water potential increased with the vase life of 'First Red' rose cut flowers but decreased with increasing sucrose concentrations. Vase life and flower diameter was highest with sucrose (3 per cent) concentration. Monteiro *et al.* (2002) investigated the effect of continuous injections of exogenous sucrose on single flower postproduction longevity of attached flowers of potted miniature rose (*R. hybrida* cv. Meijikatar). Higher the uptake rate of sucrose solution the longer the flowers lasted. Exogenously supplied sucrose was consumed by increased respiration and consequently, at day 6 after anthesis, no difference was found in non-structural carbohydrate levels between water and sucrose treatments. However, percent of soluble sugars in the stem was higher in the sucrose-infused plants, suggesting that exogenous sucrose supply not only served as an extra source of respirable carbohydrates but also released stored carbohydrates to flower respiration. At flowers death, leaf soluble sugars and total non-structural carbohydrates were higher in the sucrose infusion treatment and, independently of infusion treatment, flower soluble sugars and total non-structural carbohydrates positively correlated with flower longevity.

Pulsing solution containing sucrose (10 per cent) + STS (1 mM) for 8 hours and holding solution consisting of sucrose (2 per cent) + STS (10 ppm) were found best for dry cold stored cut carnation flowers (Suman *et al.*, 2002). Pal *et al.* (2003) reported increase in vase life and floret opening of gladiolus cv. Pink Friendship kept in preservative solution containing sucrose (4 per cent) + $Al_2(SO_4)_3$ (300 ppm). Vase life of cut rose cv. First Red increased with increasing sucrose concentration (up to

1.5 per cent) in combination with $Al_2(SO_4)_3$ and decreased with further increase in sucrose concentration (Singh *et al.* 2003).

Singh *et al.* (2003) studied the effect of holding solutions on vase life and quality of China aster cv. Shashank flowers. Holding solutions were found beneficial in increasing vase life and quality of cut flowers over control (water treated). Maximum vase life (15.88 days) and solution uptake (40.13 ml) were recorded with sucrose (1 per cent) + 8-HQC (200 ppm) over the control (8.42 days and 25.22 ml, respectively). Fresh weight of cut stems increased at 3^{rd} day and 6^{th} day in vase but declined at senescence. Similar changes were observed in dry weight also. Maximum increase in flower diameter (7.35 cm) was recorded with sucrose (3 per cent) + $AgNO_3$ (20 ppm) + citric acid (75 ppm) over the control (5.99 cm). Holding solution containing sucrose (1 per cent) + 8-HQC (200 ppm) was found best in prolonging vase life of China aster cut flowers. Singh *et al.* (2004) reported increase in bud opening, vase life and flower size of Queen Elizabeth cut rose after keeping cut stems in holding solution containing sucrose (1.5 per cent) + $Al_2(SO_4)_3$ (300 ppm). In Gladiolus cv. White Prosperity, vase life, per cent floret opening and total sugar content of florets were higher than control when cut spikes were kept in holding solution containing sucrose (4 per cent) + $Al_2(SO_4)_3$ (400 ppm). Sugar content of spikes treated with $Al_2(SO_4)_3$ was on par to control, thus indicating role of exogenous sugars in prolonging vase life of cut spikes. Vase life of 10.25 days was recorded in 'Mercedes' cut rose pulsed with D-fructose (3 per cent) + 8- HQC (150 ppm) for 24 hours and dry cold stored at 4^0C for 3 days (Vinod Kumar and Bhattacharjee, 2004).

Ichimura *et al.* (2005) compared postharvest characteristics of *R. hybrida* cv. Delilah and Sonia. Petals of 'Sonia' flowers kept in water did not reflect fully and showed blueing. Treatment with sucrose + 8-HQS markedly promoted petal reflection and inhibited blueing. Maitra and Roychowdhury (2005) reported that cut flowers of *Anthurium andraeanum* cv. Nitta kept in holding solution containing sucrose (5 per cent) + 8-HQS (400 ppm) had maximum vase life (28.17 days) over the cut flowers simply kept in distilled water (13.33 days). Solution containing sucrose (4 per cent) + $Al_2(SO_4)_3$ (300 ppm) resulted in the greatest flower diameter (6.93 cm) and longest vase life (13.13 days) in 'Snow Princess' gladiolus (Ram *et al.*, 2005). Srivastava *et al.* (2005) observed that pulsing treatment with sucrose (20 per cent) + $Al_2(SO_4)_3$ (200 ppm) was found better for most of the traits of gladiolus cv. Nova Lux.

Sharma and Singh (2006) reported that sucrose (4 per cent) + 8-HQC (200 ppm) were effective in enhancing fresh weight and prolonging the vase life of gladiolus cv. White Friendship over the cut spikes simply kept in distilled water.

2.2 COLD STORAGE

Storage of cut flowers is a pre-requisite for orderly marketing so as to avoid or minimize postharvest losses. Cold storage provides growers capability of extending the useful life of cut flowers and therefore, widening market window for the product. At lower temperatures, flowers have a lower respiration rate and consume their stored energy much slower. Other important manifested advantages of cold storage are reducing respiration and internal breakdown by enzymes, reducing water loss and wilting, slowing the growth of disease organisms, reducing the production of ethylene and providing time for proper handling, packaging and marketing. During the entire cold storage period, it is important to maintain a stable and uniform temperature, relative humidity, circulation of air, and sanitation of the storage room (Goszezynska and Rudnicki, 1988; Nowak and Rudnicki, 1990).

Cold storage is the most common method used commercially for cut flowers. Cold storage is of two types viz., dry and wet storage. In case of wet cold storage, stem bases are kept in water or in preservative solution for the intended period. Storage temperature during wet cold storage is usually kept at 3^0 to 4^0C, which is slightly higher than dry cold storage. In wet cold storage cut flowers are stored for a short duration (say 1 or 2 days).

In dry cold storage, flowers are sealed in plastic bags to prevent the loss of moisture. This method is followed for long distance transportation and long-term storage. Cold storage for more than 6 days reduced vase life of cut roses (Jensen and Hansen, 1972). De Boer and Witmondt (1975) observed that pre market storage of roses in water at a temperature range of 0^0 to 10^0C always gave considerably better results than dry storage period. Increase in temperature and storage duration resulted in decreased vase life in 'Baccara' and 'Sonia' cut roses (Amariutei and Burzo, 1982). Pulsing of cut rose with sucrose (3 per cent) prior to cold storage was beneficial for longer vase life (El-Gamasy and Hashem, 1984). Staby *et al.* (1984) emphasized that under normal refrigeration (NR) roses could be stored up to 2 weeks and they still show at least 61 per cent of their non-stored original vase life. Increase in vase life was recorded when cut rose cv. Sonia was dry cold stored at 4^0C in closed refrigerated containers (Van Beek, 1984).

Ketsa and Dadaung (1989) found that cut rose cv. Christian Dior sealed in non- perforated polyethylene bags kept dry at 3 ± 1^0C had best quality and longest storage life of 12 days and cut flowers stored under above conditions did not differ significantly in vase life for freshly cut flowers without storage. Vase life of 'Gabriella' cut rose dry cold stored at 1^0C for 3 weeks was 4 days shorter as compared to fresh ones (Mor *et al.*, 1989). Lukaszewska and Gorin (1989) reported that wet cold storage of cut 'Sonia' rose flowers resulted in slight opening of corolla. Serrano *et al.* (1992) reported storage of rose cv. Visa flowers at 4^0C, the rate of ethylene production was maintained at very low levels and was unaffected by the length of the cold storage period. Cut rose cv. Super Star could be wet cold stored at 4^0C for 4 days without any deteriorative effect on subsequent life in vase and quality of flowers (Rajan, 1993). Cool chamber storage of tuberose florets resulted in delayed symptoms of wilting, maintained freshness and white colour for a long time, in addition to delay and reduction in rotting leading to increased storage life (Madaiah and Reddy, 1994).

De and Bhattacharjee (1997) recorded that diameter of first and third floret, increase in spike length, and vase life of gladiolus cv. Dhanvantari were improved following storage at temperature 0.55^0 to 1.66^0C. Devecchi *et al.* (1997) reported longevity of cold stored cut rose 'Serena' subjected to pulsing treatment of sucrose and 8-HQC were comparable to that of cut rose simply kept in water. Cushman *et al.* (1998) showed that flowers of pot roses cvs Meijikatkar and Meirutral stored at 4^0C had longest vase life, best flower quality and least leaf abscission.

Sivasamy (1998) recommended that cut 'Raktagandha' rose could be wet cold stored for 5 days at 3^0C without decline in vase life over control flowers. Further he concluded that pulsing with sucrose (3 per cent) and 8-HQC (150 ppm) for 24 hours prior to wet cold storage at 3^0C improved keeping quality of cut rose cv. Raktagandha. Cut roses stored for 3 days at 4^0C gave maximum vase life compared with other treatments and freshly cut unstored flowers (Palanikumar *et al.*, 1999). Delay in onset of bent neck, increased solution uptake, flower diameter, and prolonged vase life were recorded in cut 'Red Sandra' rose stored in wet condition or at low temperature as compared with that stored in dry or room temperature (Bang-Chang Seok *et al.*, 1999). El-Saka *et al.* (2000) studied the effect of storage temperature and duration on nine rose cultivars viz. 'Carman', 'Sacha', 'Escada', 'Raphaela', 'Sweetnesse', 'Papillon', 'Konfetti', 'Tennessee', and 'Hollywood'. Generally, all cultivars stored at 5^0C showed less flower weight loss than those stored at 10^0C for the same periods. Flower weight loss increased with extended storage periods. Flower quality after five days from holding in opening solution was better at 5^0C for 5, 10 and 15 days than that at 10^0C for the same periods. Flower quality decreased with increasing storage temperatures and periods. Sivasamy and Bhattacharjee (2000) concluded that wet cold storage of cut rose cv. Raktagandha at 3^0C was beneficial for improving quality and longevity as compared with those stored at 8^0C. Prolonged storage period reduced water uptake, flower diameter and vase life of cut roses irrespective of the cultivars and storage temperature in general (Palanikumar and Bhattacharjee, 2001). Palanikumar and Bhattacharjee (2001) conducted investigation on varietal performance of different cut rose cultivars under cold storage. They reported cold storage of cut roses at 4^0C as best in terms of vase life, flower diameter and water uptake. Cut 'Raktagandha' rose could be wet cold stored up to 4 days at 4 ± 1^0C without any significant reduction in vase life (Vidhya Sankar and Bhattacharjee, 2002). Faster opening of buds under wet cold storage than dry cold storage was also observed.

Rose cultivars 'Noblesse' and 'Mercedes' after pulsing with DMSO (2 per cent) for 15 minutes can be wet cold stored at 4^0C for 2 and 4 days, respectively, without affecting their ultimate vase life and quality over the control flowers (Vinod Kumar *et al.*, 2002). Pal *et al.* (2003) reported that angle of neck bending was significantly reduced in high humidity storage with increased flower diameter and marketability. The high humidity cool chamber also showed better retention of petal anthocyanin with low respiration and ethylene evolution by the whole stalk. Senescence of flowers was rapid at ambient temperature with high rate of ion leakage from petals and high respiration rate. Addition of sucrose and HQC in the holding solution further helped in maintaining the overall quality of cut flowers in high humidity storage condition.

Vinod Kumar *et al.* (2003) reported that pulsing and storage improved the postharvest life and quality of tuberose cv. Double cut flowers. Among the different chemicals tried, pulsing with sucrose (10 per cent) + $Al_2(SO_4)_3$ (250 ppm) for 12 hours and cut spikes stored for 4 days at 4^0 to 5^0C as the best in respect of rachis length, delay in wilting of first, third and last opened floret pair, extension of useful life, retention of fragrance, water uptake, opening of florets, increase in diameter and length of first, third and last opened floret pair, and vase life over the cut spikes which were not pulsed but dry cold stored as well as cut spikes neither pulsed nor stored.

2.3 VARIETAL DIFFERENCES IN POSTHARVEST LIFE OF CUT FLOWERS

An important quality aspect of cut flowers is the behaviour of the flower in a vase. This vase life behaviour varies largely. Even within a crop, large differences in vase life are present among cultivars. Vase life of cut flowers is contingent on many factors, some of them not inherent in the flowers itself. Nowak and Rudnicki (1990) described differences in vase life among cultivars of some cut flower species like *Alstroemeria*, *Anthurium*, Carnation, *Gerbera*, rose and lily, and they suggested that cut flowers with thicker stems that produce lower amounts of ethylene, last longer. Vase life of cut roses differs due to differences in senescence behaviour (Accati and Jona, 1989; Wu *et al.*, 1991), lignification (Zieslin and Ben-Zaken, 1991; Zamski *et al.*, 1997) and storage behaviour (Mor, 1989). Cut 'Golden Wave' rose wilted earlier and had shorter vase life because of poor stomata closure of leaves under water stress conditions (Mayak *et al.*, 1974). They further recorded difference in vase life of 'Super Star' and 'Golden Wave' cut roses. Roses differ considerably in their sensitivity to 'bent neck' (Zieslin *et al.*, 1978). Evaluation of 10 rose cultivars for vase life in aeionized water was studied. Cultivar Prominent exhibited longest vase life of 10.1 days while cv. Sonia lasted only for 6.9 days (Ferreira and Swardt, 1981). Gherghi *et al.* (1983) recorded differences in longevity of cut roses viz., 'Mercedes', 'Zorima', and 'Marimba' (10.20, 7.20 and 8.40 days, respectively) in distilled water. Cut rose cv. Christian Dior held in tap or well water experienced a shorter vase life than those held in distilled water, deionized water or rainwater. However, vase life of flowers was increased, when tap or well water was passed through a deionizer (Phavaphutanon and Ketsa, 1988). Riodel *et al.* (1989) reported rose cv. Sonia could be stored up to three weeks under low pressure (LP) and retain, 68 per cent of their original vase life while those stored in normal refrigerator (NR) retained only 53 per cent. Variation in longevity of cut gladiolus spikes was recorded by Saini *et al.* (1991). According to their report, vase life was longest (11.5 days) for 'Pusa Suhagin' and shortest (6.31 days) for miniature. Bhattacharjee (1993) evaluated the vase life of

11 cultivars of cut roses. Longest vase life (10.6 days) was exhibited by 'Raja Surendra Singh of Nalagarh', followed by 'Dr. B.P. Pal' (9.8 days). However, the greatest diameter (10.7 cm) of flower was measured in cultivar 'Arjun'. De (1995) evaluated 32 cultivars of cut roses and concluded that cv. Anjelique expressed the longest vase life (12.2 days) while the cv. Preyasi the shortest (5.3 days). However, flower diameter varied among the cultivars.

Palanikumar and Bhattacharjee (2001) studied the effect of wet cold storage on three cut rose cultivars viz., 'Golden Gate', 'Raktagandha', and 'Queen Elizabeth'. They found that 'Raktagandha' gave maximum vase life of 10.0 days at 4^0C after three days storage and 8.5 days at 8^0C after one-day storage. Kim and Lee (2002a) investigated changes in bent neck, neck strength, water content and water balance, and tissue pH of cut roses cvs First Red, Saphir, Red Velvet, and Sonia. All these cultivars were kept in preservative solution containing sucrose (3 per cent) + 8-HQS (200 ppm) + ethionine (0.1 mM). Vase life of 'First Red' and 'Saphir' was much longer than that of 'Red Velvet' and 'Sonia'. 'Red Velvet' flowers held in deionized water showed severe bent neck within eight days after harvest. Neck strength of 'First Red' and 'Saphir' was stronger than that of 'Red Velvet' and 'Sonia'. Water contents of neck, upper stem and lower stem were decreased in 'Red Velvet', which showed frequent bent neck, and short vase life, whereas 'First Red' showed no bent neck and long vase life and recorded constant water content during senescence. Water content was significantly increased when cut flowers were held in preservative solutions compared with water. Tissue pH of flowers held in deionized water was greater than that of those held in preservative solution. Increased tissue pH caused rapid blueing and yellowing of petals. Vinod Kumar *et al.* (2003) reported that pulsing of cut roses 'Mercedes' and 'Noblesse' prior to wet cold storage (4^0C) increased flower diameter and vase life compared to untreated cut flowers (control). Yoo *et al.* (2003) reported that silver thiosulphate (STS) (0.5 mM) + $Al_2(SO_4)_3$ (700 ppm) and STS (0.5 mM) + $Al_2(SO_4)_3$ (700 ppm) + glucose (1 per cent) were very effective in extending vase life of 'Red Sandra' and 'Rote Rose' but showed little effect in 'Saphir' cut rose.

Ichimura *et al.* (2005) evaluated postharvest characteristics of two rose cultivars viz. 'Delilah' and 'Sonia'. Vase life of 'Delilah' was 10.6 days whereas that of 'Sonia' 5.6 days. Petals of 'Sonia' flowers kept in water did not reflect fully and showed blueing. But, treatment with sucrose + 8–HQS markedly promoted petal reflection and inhibited blueing. In contrast, 'Delilah' flowers kept in water reflected fully and did not show blueing. Concentrations of glucose, fructose and sucrose in petals of 'Delilah' were much higher throughout experimental period than those of 'Sonia'. Starch concentration in petals of 'Sonia' was higher than in 'Delilah'. Sensitivity to ethylene in 'Delilah' was greater than in 'Sonia'. The complete petal reflection and longer vase life of 'Delilah' than 'Sonia' flowers may be attributed to higher soluble carbohydrate concentrations in petals of the former.

Nell and Leonard (2005) investigated effect of storage temperatures on 14 cultivars of cut rose (*R. hybrida*). Vase life decreased (2 to 8 days) as storage temperature increased from 2^0C to 10^0C. 'Saturn' and 'Charlotte' were the only cultivars where vase life was unaffected by storage temperature. High temperature reduced or prevented adequate flower opening on 'Black Magic', 'Classy', 'Gabriele', 'Leonidas', 'Madame Delbard', 'Poison', 'Red Jewel', and 'Valentino', while 'Eliza', 'Charlotte', 'Orlando' and 'Saturn', opened adequately at all temperatures. 'Red Unique' and 'Marylse' had less than optimal flower opening, regardless of storage temperature. The most tolerant to stressful storage conditions were 'Charlotte', 'Orlando' and 'Saturn'.

2.4 GAMMA IRRADIATION AND POSTHARVEST LIFE AND QUALITY OF FLOWERS

In agriculture one of the potential uses of atomic radiation, particularly gamma rays; is in the preservation of food products such as fruits, vegetables including mushrooms, cereals, pulses, spices, etc. by preventing senescence, insect infestation and microbial contamination. Irradiation technology is employed at quarantine stage in the imported cut flowers for insect disinfestations. Little work has been undertaken to evaluate the effect of gamma rays on postharvest life and quality of cut flowers.

Biologically it is now accepted that DNA is the most critical target of radiation (Greez *et al.*, 1983). Other effects of radiation are on metabolic functions, bond breakage in proteins, depolymerization of starch (Grunewald, 1984) and ethylene production (Thomas, 1988).

In tulips, no change was observed by Hekstra (1966). Irradiation with 0.10 to 0.50 kGy decreased the opening of protea cut flowers and enhanced the blackening of foliage (Haasbroek *et al.*, 1973). Variable responses of gamma irradiation in roses with different cultivars were reported by Dupuy (1975).

Munasiri *et al.* (1987) reported complete elimination of recoverable microorganisms in black pepper, turmeric and red chilli pepper after a 10 kGy dose. With the same amount of gamma irradiation dose, reduction of aerobic microbial population was reported in fresh ground ginger by Andrews *et al.* (1995). Sensory qualities of flavour, colour and odour of ginger powder were similar for treated and untreated ginger.

With gamma irradiation dose of 0.30 kGy, all stages of two-spotted spider mite (*Tetranychus urticae*) could be disinfested from rose cut flowers (Goodwin and Wellham, 1990). Seaton and Joyce (1992) observed that gamma irradiation doses greater than 0.05 kGy for Geraldton wax (*Chamelaucium uncinatum*) cultivar 'Purple Pride', greater than 0.1 kGy for *Banksia hookeriana* and greater than 1.0 kGy for red and green kangaroo paw (*Anigozanthos manglesii*) caused significant reductions in flower and foliage vase lives. In chrysanthemum cut flowers, same affect was reported by Chiu (1986).

Bhattacharjee and Roy (1994) recorded that gamma irradiation dose of 0.50 kGy markedly improved the postharvest life and quality of cut rose cv. Priyadarshini. It was also observed that higher doses of gamma irradiation (0.25 to 1.0 kGy) inhibited the full flower expansion but prolonged the vase life of 'Raktagandha' cut rose. Gamma irradiation dose of 0.025 to 0.10 kGy prolonged the longevity of cut flower and enhanced flower bud opening (De *et al.*, 1997). Gladon *et al.* (1997) reported that cut rose 'Royalty' (*Rosa hybrida* L.) after treating with 0.25 and 0.50 kGy of electron beam irradiation at 10 Mev and a dose rate of 45 kGy/min. slowed the rate of flower opening without decreasing flower quality. In chrysanthemum cut flowers it was studied that irradiation damaged not only pathogens but also cellular constituents. Prevention of deterioration of cellular constituents in chrysanthemum cut flowers by sugar and floral preservatives was reported (Nakahara *et al.*, 1998). Sucrose reduced the irradiation induced physiological deterioration of chrysanthemum cut flowers when kept in sucrose solution after irradiation (Hayashi and Todoriki, 1996).

Chrysanthemum cv. Nilima loose flowers after treating with irradiation dose of 0.10 kGy can be stored for 4 days at 4^0C without affecting their longevity (Vinod Kumar *et al.*, 2002). Bansidhi *et al.* (2004) reported that gamma irradiation dose of 0.350 kGy was sufficient to sterilize all adults of orchid thrips (*Thrips palmi*). Takano (2004) investigated that two spotted spider mite (*Tetranychus urticae*) which was more tolerant of irradiation than other species of cut flower pests, such as the American serpentine leafminer (*Liriomyza trifolii*), the green peach aphid (*Myzus persicae*), the Comstock mealybug (*Pseudococus comstocki*), the melon thrips (*Thrips palmi*), the onion thrips (*Thrips tabaci*) and common cutworm (*Spodoptera litura*), was submitted to gamma irradiation dose of 0.400 kGy with *Alstroemeria* sp., stock (*Mathiola incana*) and carnation (*Dianthus caryophyllus*). With this irradiation dose, approximately 17,000 eggs and 1,400 female adults were completely sterilized. Injury to the flowers was controlled to some degrees, but some injury was observed depending on flower cultivars. Hamidah *et al.* (2006) studied the tolerant dose of gamma irradiation for different cut flowers in order to sterilize red spider mite (*Tetranychus piercie).* They found that gamma irradiation dose of 0.350 kGy may be applied as a quarantine dose for sterilizing all stages of red spider mite. Tolerant dose for roses is 0.100 kGy, for carnation 0.200 kGy, and for orchids 0.100 to 0.300 kGy depending on the variety tested. Cut chrysanthemum can tolerate 0.200 to 0.400 kGy depending on the variety tested. However, chrysanthemum in sucrose (4 per cent) solutions can tolerate doses of 0.750 kGy. Hence their findings reveal that chrysanthemum cut flowers are only suitable for sterilizing red spider mite through gamma irradiation dose of 0.350 kGy.

Prado *et al.* (2006) studied the effect of gamma irradiation (^{60}Co) on nuts of groundnut mycoflora. Disinfected nuts irradiated at 5 kGy showed reduced fungal infection and total fungi elimination was obtained after storage with irradiation at 10 kGy. So gamma irradiation at > = 10 kGy appeared to be efficient against groundnuts mycoflora.

2.5 RESPIRATION

The rate of respiration is directly related with ethylene production. So the main objective in postharvest biology and technology of flowers is to bring down the respiration rate so as to extend postharvest life and quality of flowers. The techniques like precooling, cold storage, etc. have been successfully employed so as to retard respiration rate and hence extend postharvest life and intrinsic quality of flowers.

As early as 1936, Laurie reported that respiration rate had a bearing on the length of life of any cut flower. Aarts (1957a) observed that the individual flower parts responded the same way as whole flower when respiration was measured. Siegelman *et al.* (1958) described respiratory pattern in developing rose petals, which was dependent on the location of the petals in the flower. Coorts (1973) found that flowers with highest rate of respiration had the poorest keeping quality. He noted that the short lived rose had a respiratory rate of 414 cc CO_2/kg/h as compared to long lived which had a respiratory rate of 289 cc CO_2/kg/h. Nichols (1973) reported that gradual decline in the respiration rate in ageing flowers may be caused due to decline in supply of respiratory substrate mainly sugars. Exogenous sucrose helps in maintaining mitochondrial structure and functions and thereby extending the longevity of cut flowers (Kaltaler and Steponkus, 1976). Marousky (1977) reported that sucrose increased the respiratory rate of rose petals.

Buxton and Stoltz (1977) recorded a drop in the respiration of petals throughout the cut flower life. Inner petals exhibited a consistently higher respiratory rate than did the outer ones, regardless of whether the flower was kept in water or preservative solution or on the plant itself (Marrisen, 1991). Respiration rate of rose flowers cv. Visa decreased during storage at 4^0C (Serrano *et al.*, 1992). A typical drop in the respiration rate initially from harvest till the 2nd or 3rd day and then a small rise towards the end of vase life of cut 'Priyadarshini' rose was recorded by Rajan (1993). Increase in respiration rate resulted in shortened vase life and vice versa (Sivasamy, 1998). Kwon *et al.* (1999) found that cut freesia, which was dipped in silver thiosulfate (2 mM) followed by pulsing for 20 h in sucrose (10 per cent) + BA (10 ppm) + 8-HQC (300 ppm) showed less amount of respiration and ethylene production.

In cut roses, cultivars that had longer vase life, the rates of respiration at different stages of flower development and ageing were comparatively lower than that of cultivars, which lasted for a shorter time (Bhattacharjee and Pal, 1999; Singh *et al.*, 2001).

Bhattacharjee (1999b) reported in carnation and rose flowers that respiration rate increases on the first day after harvest followed by a decline to a maximum on the third and fourth day, and that it may be attributed to extensive protein breakdown and decomposition of amides and amino acids. Palanikumar *et al.* (2000) found that precooled 'Raktagandha' cut rose showed reduced respiration rate over control flowers. Precooling at 4^0C reduced the respiration rate significantly. Celikel and Reid (2005) reported a highly significant linear relationship between respiration during storage and vase life after storage of cut rose 'First Red' and gypsophila 'Bristol Fairy' flowers. Thus indicating the importance of maintaining temperatures close to the freezing point during commercial handling and transportation.

2.6 BIOCHEMICAL CHANGES

In general, vase life behaviour is the result of changes in the water balance, carbohydrate balance and development (like flower bud opening and senescence) of the cut flower during vase life. There is loss in dry matter as the petal senescence starts. Starch is broken down into sugars, which are transported to the flowers. Ammonia is released in cells because of breakdown of proteins. There are changes in the property of membranes such as increase in microviscosity and loss of phospholipids and permeability which results in leakage of pigments, sugars, mineral ions and electrolytes, thereby leading to death of tissues. Senescent petals showed increased leakage of anthocyanins and electrolytes. As the anthocyanins are located in the vacuole, their release indicates loss of selective permeability of both the tonoplast and the plasma membrane (Matile, 1997).

2.6.1 Changes in carbohydrate content

Loss in dry matter occurs due to hydrolysis of macromolecules such as starch, protein and nucleic acids. Carbohydrate content in the cut flower has a direct bearing on postharvest life and quality of cut flowers.

Paulin and Droillard (1982) emphasized that all organs of cut carnations are capable of transforming to sucrose when treated with glucose. Sucrose synthetase activity was highest in leaves, stems, sepals and ovary. Sucrose hydrolysis occurred almost exclusively in petals. Celikel and Karacali (1991) reported a reduction in sugar content in one week wet stored (0^0 to 10^0C and 85 to 90 per cent humidity) carnation flowers. Storage of spathes of anthurium (*Anthurium andraeanum* Andre) at 4^0C tended to slow the loss of reducing sugars (glucose + fructose) (Pritchard *et al.*, 1991). Cut rose cv. 'Serena' pretreated with sucrose (8 per cent) and 8-HQC (200 ppm), followed by 6 days in cold storage at 2^0C had 60 per cent more carbohydrates. At day 4 and 5 there was a peak in the value of carbohydrates. This could be due to the fact that flowers being in stress conditions hydrolyzed their nutritional reserves (Garibaldi and Deambrogio, 1993).

In Geraldton waxflower (*Chamelaucium uncinatum*) flowers cut and maintained individually, sugar and protein levels decreased rapidly after harvest suggesting their use as respiratory substrates. Respiration rates were initially high (1432 ml/ per h) for the flowers from harvested sprigs, and declined during vase life (Olley *et al.*, 1996).

Bhattacharjee (1998) recorded a change in the level of total soluble sugars (TSS), reducing sugars (RS) and total free amino acids (TFAA) at harvest, on 3^{rd} day in vase and at senescence in the 'Super Star' cut rose. Exogenous levels of carotenoids, soluble carbohydrates and soluble proteins were greater in sucrose fed *Sandersonia aurantiaca* flowers than control (Eason *et al.*, 1998).

Ichimura *et al.* (1999) observed that concentration of glucose, fructose and sucrose in the petals of 'Sonia' roses was increased by sucrose and HQS treatment. Positive correlation between sucrose concentration in petals and flower diameter or vase life was obtained. Palanikumar *et al.* (2000) reported that the total sugar content decreased in the senescence cut rose petals as compared to that of fresh ones. Kim and Lee (2002b) observed that cut roses 'First Red' and 'Saphir' having long vase life maintained high total sugar contents at and after harvest. This may indicate that vase life and carbohydrate supply are closely correlated. Sucrose supplied by preservative solutions existed as reducing sugar in flowers. Thus supplement of materials for carbohydrate metabolism in flower growth and development is essential for extending vase life. Mariam *et al.* (2003) studied that in pulsed cut rose 'Golden Gate' flowers, total starch content increased over the untreated control. TSS content of petals increased on the 3^{rd} day of vase life and at senescence. Pulsing reduced the TFAA content of petals. Flowers subjected to cold storage and pulsed with DMSO (2 per cent) recorded the highest total starch and TSS contents, lowest TFAA content, and longest vase life. Singh *et al.* (2004) found that when gladiolus cv. White Prosperity cut spikes were held in holding solution containing sucrose (4 per cent) + $Al_2(SO_4)_3$

(400 ppm), vase life, percent floret opening and total sugar content of florets were significantly higher than control. Total sugar content of florets after 3, 6, 9, and 12 days was 177.81, 150.67, 146.20, and 127.94 mg/g dry weight, respectively.

Shiva and Bhattacharjee (2006) reported that pulsing of cut rose with sucrose (3 per cent) + 8- hydroxyquinoline citrate (8-HQC, 150 ppm) for 24 hours prior to wet cold storage (3^0C) significantly increased the total soluble sugars and total starch contents in petal and leaf tissues in both the stages i.e. immediately after storage and on senescence than those treated with distilled water over 8 days storage. Irrespective of pulsing treatments and durations of storage, total soluble sugars increased with corresponding reduction in total starch content. Prolonged vase life of cut rose was associated with the increase in total soluble sugars and total starch as influenced by pulsing treatment.

2.6.2 Changes in total free amino acids (TFAA) content

Presence of glucose or fructose in the holding solution suppressed the accumulation of free amino acids in senescence cut dahlias (Lukaszewska, 1980). In cut roses cvs Dame de Couer and Lady X the concentrations of total and basic free amino acids increased throughout vase life while that of acidic free amino acids fluctuated at first and then increased sharply when petal senescence began. Addition of a preservative containing sucrose (2 per cent) + 8-HQC (250 ppm) + citric acid (500 ppm) + $AgNO_3$ (25 ppm), reduced the level of increase in amino acid concentration (Gao, 1991; Gao and Wu, 1990).

De *et al.* (1996) observed minimum amount of TFAA in petals and leaves of cut 'Super Star' rose treated with sucrose (2 per cent) + STS (0.2 mM) + 8-HQC (300 ppm). Increase in free amino acids was observed as day lily (*Hemerocallis fulva*) flowers developed, opened and senescent (Sultan and Farooq, 1996). Pulsing of 'Raktagandha' cut rose with sucrose (3 per cent) + 8-HQC (150 ppm) for 24 hours prior to wet cold storage at 3^0C decreased the increase in TFAA content after storage and on senescence (Sivasamy, 1998). A lower content of TFAA was correlated with longer vase life and quality of flowers. Significant fall in TFAA content over the untreated flowers was reported by Bhattacharjee (1999b) in 'Sonia Meilland' cut rose when kept in holding solution containing chloride salts. Decrease in membrane proteins in senescence cut roses cvs Mercedes and Baroness was delayed by $CaCl_2$ treatment (Torre *et al.*, 1999).

Cai *et al.* (2000) reported the effect of salicylic acid on vase life of cut roses. Salicylic acid decreased the malondialdhyde and free proline content. Moreover, it also delayed senescence and water stress in cut rose flowers.

Total free amino acids (TFAA) content of 'Raktagandha' cut rose, which was precooled and packed recorded lesser amount and more vase life than unprecooled and packed flowers (Palanikumar, 2000). Further, it has been reported that there is a correlation between free amino acid content and senescence. When senescence advances the protein breakdown starts and there is increase in the amount of free amino acid content in petal samples. Mariam *et al.* (2003) reported in 'Golden Gate' cut rose that prolonged vase life was associated with high starch content, total phenol concentrations, low soluble sugars and total free amino acids in the petals.

Plate 1. Cut roses grown in greenhouse

Plate 2. A greenhouse view of 'Golden Gate' cut rose

3. MATERIALS AND METHODS

The present investigation was undertaken at the Division of Floriculture and Landscaping, Indian Agricultural Research Institute, New Delhi-110012, during the period from January 2005 to December 2006. The investigation comprised of different experiments under following broad aspects.

1. Effect of gamma irradiation, pulsing, and dry and wet cold storage on vase life of cut roses
2. Effect of gamma irradiation, pulsing, and wet cold storage on physiological and biochemical changes in cut roses

Cut flowers of these cultivars were procured from Greenhouse of Centre for Protected Cultivation Technology, Indian Agricultural Research Institute, New Delhi (Plate 1). Flower stems were harvested randomly in the morning at 9: 00 to 9:30 A.M. Plants of all three cultivars were subjected to uniform treatments of fertigation, irrigation, and spraying of insecticides and fungicides as per agro-technological schedule under the fan pad cooling system greenhouse.

3.1 ROSE CUT FLOWER CULTIVARS AND AGRO-TECHNIQUES FOLLOWED FOR RAISING THEM

Three rose cultivars viz., Golden Gate, Mercedes, and Noblesse were selected for conducting various experiments.

Golden Gate

It is a Floribunda type rose variety. In India, Pune and Bangaluru regions are known for protected cultivation of this variety on a commercial scale. Flower buds are medium sized golden–yellow in colour. Stem length varies from 50 to 60 cm. Vase life of cut flowers is 12 days. Average yield is 210 cut stem per sq. m. per year (Plate 2).

Mercedes

It is a Floribunda type having small orange red coloured buds with dark green foliage. Stem length is 45 cm. Vase life of cut flowers is 14 days. Average yield is

Plate 3. A greenhouse view of 'Mercedes' cut rose

Plate 4. A greenhouse view of 'Noblesse' cut rose

Plate 5. Commercial stage of harvest of 'Golden Gate' cut rose

Plate 6. Wet cold storage of 'Mercedes' cut rose

300 cut stems per sq. m. per year (Plate 3).

Noblesse

It is a Hybrid Tea variety. Attractive pink coloured flower buds are borne on erect thorny stems. Stem length is 60 cm. Vase life of cut flowers is 14 days. Average yield is 260 cut stems per sq. m. per year (Plate 4).

3.2 EFFECT OF GAMMA IRRADIATION, PULSING, AND DRY AND WET COLD STORAGE ON VASE LIFE OF CUT ROSES

Cut flowers of aforementioned cultivars were harvested with 30 cm long stem with the help of clean and sharp secateur by giving a slanting cut. Cut flowers were harvested when all the sepals were at right angles to the bud and outer petals had started unfurling from the tip (Plate 5). This stage was found to be the right stage of harvest by Bhattacharjee (1992) for better postharvest life of rose flowers. These harvested flowers were transferred immediately to a bucket containing freshly collected tap water (3 cm deep) and taken to laboratory. The flowers were again cut to a stem length of 20 cm retaining 2 uppermost compound leaves since the gamma chamber length is 20 cm. Cut flowers were then subjected to different gamma irradiation doses (kGy) which are as under.

- 0.025
- 0.05
- 0.10
- 0.20
- 0.40
- 0.60

Five cut flowers were selected for one dose for a single day cold storage.

3.3 GAMMA CHAMBER

Cobalt-60 was used as source of gamma rays. It is kept in the form of thin rods all around steel housing and protected heavily with lead shield, which has a long shaft having provision for placing the sample moving up and down. This shaft is usually automatically operated through power but can also be manually operated. After placing the sample (cut roses) the shaft is moved down to irradiation source. When the sample gets irradiated, shaft moves up.

Mode of operation

When the sample chamber is up, the power is switched off and the sample is

Plate 7. Vase life evaluation of 'Golden Gate' cut rose in ambient conditions

Plate 8. Reduction in flower opening of 'Mercedes' cut rose treated with gamma rays dose 0.60 kGy

placed inside the chamber. The uniformly prepared cut stems were kept in a glass beaker with cut ends of stems dipped in 3 cm deep water to prevent vascular occlusion. The beaker containing cut stems was kept in the gamma chamber. The chamber is locked and the power is switched on. Mains keys and computer keys on the control panel are also switched on. After loading the sample, with the help of keypad, required dose of irradiation is fed and the time required for that dose to irradiate the sample comes automatically. After this the 'DOWN' switch was pressed to move the chamber down to the irradiation zone. When the irradiation was completed, the 'UP' switch pressed to bring the chamber to unloading position. The sample was removed from the chamber by opening the chamber door. During gamma irradiation the sample get heated so care was taken to employ higher doses at the beginning for avoiding injury to cut flowers.

After gamma irradiation, the cut flowers were brought to laboratory of the Division of Floriculture and Landscaping and pulsed with sucrose (3 per cent) for 24 hours. Thereafter the cut flowers (five each) were packed in 80 gauge thickness polyethylene bags (40 cm x 25 cm). The open end of the bags was folded twice and then stapled separately. Five holes of uniform size were made in each bag for ventilation. The packed cut flowers were dry cold stored at 2^0C for 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 days. In this experiment there were 11 treatments including control (water-treated cut flowers). The experiment was laid out with Completely Randomized Design (CRD) replicated thrice.

In another experiment, irradiated and pulsed cut flowers were wet cold stored at 2^0C for 2, 3, 4, 5, 6, 7, 8, 9, and 10 days. Cut ends of five cut flowers were dipped in 2 cm deep tap water for a single day wet cold storage. Five cut flowers were kept in tap water during wet cold storage for a single day treatment (Plate 6). In this experiment, there were 10 treatments including control (water-treated cut flowers). This experiment was also laid out with Completely Randomized Design (CRD) replicated thrice.

After different storage treatments, the cut ends of flower stems were dipped individually in equal sized graduated large test tubes (25 x 200 mm) containing 60 ml tap water. Vase life of cut flowers was evaluated in ambient conditions (Plate 7). Rajan and Bhattacharjee (1995) reported that tap water significantly improves the vase life of cut roses over single and double distilled water. Tap water also results in higher water uptake by the cut stems compared to distilled water. Hence, tap water was used in this study also. Van Meeteren *et al.* (2000) also reported that deionized water gave a sharp decrease in fresh weight of chrysanthemum cut flowers after 1 to 3 days whereas this decrease was absent in tap water.

3.4 OBSERVATIONS RECORDED

i. Fresh weight (g)

- on day of harvest
- after bringing from cold storage
- on 3rd day in vase
- at the end of vase life

The fresh weight (g) of cut flowers at the abovementioned stages was recorded using a digital weighing machine. Care was taken that the cut ends of flowers were dipped in water during weighing operations. The increase/decrease in the fresh weight of cut flowers was recorded over the initial fresh weight at harvest.

ii. Dry weight (g)

- on day of harvest
- after bringing from cold storage
- on 3rd day in vase
- at the end of vase life

This was recorded after drying cut flowers in a hot air oven at 70^0C for two days. The increase/decrease in the dry weight of cut flowers was recorded over the initial dry weight at harvest.

iii. Flower diameter (cm)

- on day of harvest
- after bringing from cold storage
- on 3rd day in vase
- after complete flower expansion

This was measured on two perpendicular axis and average of the two was taken.

iv. Water uptake (ml)

This was measured as the difference in the amount of water in the test tube from initial to final quantity on daily basis.

v. Vase life (days)

The cut flowers kept in test tubes containing tap water were observed every day for senescence and the total period of vase life was noted in days. The end of useful vase life of flowers was marked by the appearance of bent neck symptom or that of other symptoms like wilting, yellowing of leaves, blueing, loss of petals, drying up of outer petals or opening of the centre.

3.5 EFFECT OF GAMMA IRRADIATION, PULSING AND WET COLD STORAGE ON PHYSIOLOGICAL AND BIOCHEMICAL CHANGES IN 'GOLDEN GATE' CUT ROSE

Cut flowers of rose cv. Golden Gate were gamma irradiated with 0.025 kGy (best dose) and pulsed with sucrose (3 per cent) for 24 hours and then wet cold stored at 2^0C for 2, 3, 4, 3, 5, 6, 7, 8, 9, and 10 days. One set of flowers was kept in vase without irradiation, pulsing and storage, which served as control.

3.6 OBSERVATIONS RECORDED

i. Fresh weight of cut flower (g)

- on day of harvest
- after bringing from cold storage
- on 3rd day in vase
- at the end of vase life

The fresh weight (g) of the cut flowers at the abovementioned stages was recorded using a digital weighing machine. Care was taken that the cut ends of roses were dipped in water during the weighing operations. The increase/decrease in the fresh weight of cut flowers was recorded over the initial fresh weight at harvest.

ii. Dry weight (g)

- on day of harvest
- after bringing from cold storage
- on 3rd day in vase
- at the end of vase life

This was recorded after drying cut flowers in a hot air oven at 70^0C for 2 days. The increase/decrease in the dry weight of cut flowers was recorded over the initial dry weight at harvest.

iii. Flower diameter (cm)

- on day of harvest
- after bringing from cold storage
- on 3rd day in vase
- after complete flower expansion

This was measured on two perpendicular axis and the average of the two was taken.

iv. Water uptake (ml)

This was measured as the difference in the amount of water in the test tube from initial to final quantity on daily basis.

v. Vase life (days)

The cut flowers kept in test tubes containing tap water were observed every day for senescence and the total period of vase life was noted in days. The end of useful vase life of flowers was marked by the appearance of bent neck symptoms or that of other symptoms like wilting, blueing, drying up of outer petals or opening of the centre.

vi. Respiration rate

For respiration studies, the cut flowers were harvested in the morning. Basal ends of harvested flowers were dipped in 3 cm deep tap water. Then they were taken to laboratory and they were prepared uniformly 20 cm long with two uppermost compound leaves. Respiration rate of these uniformly prepared cut flowers was noted. After this, gamma irradiation dose of 0.025 kGy was employed. Immediately after the completion of irradiation, respiration rate was again noted. Thereafter irradiated cut flowers were pulsed in sucrose (3 per cent) for 24 hours and wet cold stored for 2, 3, 4, 5, 6, 7, 8, 9, and 10 days. On the day of bringing the cut flowers from cold storage the respiration rate was noted. Respiration rate was again noted on 3rd day in vase and at the end of vase life. This experiment included 10 treatments including control. The experiment was replicated thrice with Completely Randomized Design (CRD).

The respiration rate was measured using portable IRGA (Infra Red Gas Analyser, LI-6200, LI-COR Instrument Inc.). The whole flower bud respiration rate was measured by keeping the bud inside the IRGA, and stems and leaves outside the chamber. The respiration rate was measured at harvest, after irradiation, after cold storage, on 3rd day in vase, and on the completion of vase life. The LI-6200 consists of a CO_2 analyzer, a system console and a sensor housing with interchangeable chambers. The LI-6200 CO_2 analyzer was a non dispersive infra red (NDIR) calibrated for measurements of 0-1500 ppm. A pump in the analyzer circulated air from the measurement chamber to the analyzer, where CO_2 concentration was measured, and returned to the chamber.

The system console was a microcomputer that handled the data logging, calculations, data storage, and communications. The console acted as a 16-channel data logger with 48 virtual channels and up to 384 bytes RAM for data storage.

The sensor housing contained the connectors and electronics for the chamber, sensors and fans, and the intake and exhaust ports from the analyzer. The sensors included with the LI-6200 were a temperature thermocouple, a humidity sensor, an air temperature thermostat and a LI-COR quantum sensor.

The net CO_2 exchange between a flower and the atmosphere was measured by enclosing the flower in a chamber and monitoring the rate at which CO_2 concentration changed over 45 seconds. The respiration rate was then calculated using the rate of change and other factors such as the weight of the flower enclosed and the volume of enclosure and temperature. The volume of chamber (1 lit.) was corrected with the volume of the flower. CO_2 evolved was calculated in cc CO_2/g/h on a dry weight (DW) basis.

3.7 BIOCHEMICAL CHANGES DURING IRRADIATION, PULSING AND COLD STORAGE OF 'GOLDEN GATE' CUT ROSE

3.7.1 Collection, processing, and preservation of petal samples

Petal samples were collected at various stages of experiments viz., at harvest, after irradiation, after storage, 3rd day in vase, and at senescence day. Collected petal samples were dried in an oven at 70^{0}C for 2 days. The total soluble sugars (TSS) and total free amino acids (TFAA) were determined at above-mentioned stages. The dried samples were kept in an oven at 70^{0}C at least for an hour before starting biochemical estimation. Grinding of petal samples obtained after passing through 20 mm mesh sieve were kept in tightly sealed polyethylene bags.

3.7.2 Estimation of total soluble sugars (TSS)

Principle TSS is estimated by phenol sulphuric acid method. In hot acidic medium glucose is dehydrated to hydroxymethyl furfural. This forms a green coloured product with phenol and has absorption maximum at 490 nm.

Reagents used:

i. 80 per cent ethanol

Mixed 80 ml of absolute ethanol with 20 ml of double distilled water.

ii. 5 per cent phenol

Melted the phenol at 65^0C.

Mixed 5 ml of phenol with 95 ml of double distilled water.

Prepared fresh 5 per cent phenol before experiment.

iii. Standard glucose (0.2 per cent)

Added 100 mg glucose in 50 ml of 80 per cent ethanol.

Procedure Finally powdered, dried petal samples of 200 mg was weighed and transferred to a test tube. To this, 10 ml of 80 per cent ethanol was added and kept overnight. Next day this was centrifuged at 2000 rpm for 20 minutes and the supernatant was collected. From this, aliquot 40 µlit was pipetted out in 3 test tubes (as a replication). To this, aliquot 1 ml of 5 per cent phenol and 5 ml of concentrated H_2SO_4 were added and stirred well. Then the test tubes were kept in a boiling water bath for 15 minutes and the development of green colour was read in a spectrometer at 490 nm.

Standard preparation Standard was prepared by taking 0.01, 0.02, 0.03, and 0.04 ml of working standard of 0.2 per cent glucose (0.0 served as the blank). Then the volume was made up to 0.05 by adding 80 per cent ethanol. To this 1 ml of 5 per cent phenol and 5 ml of concentrated H_2SO_4 were added and heated for 15 minutes in boiling water bath. Then they were cooled rapidly and the development of red colour was read at 490 nm. The standard graph was prepared by plotting the concentration of standard on 'X' axis and absorbance on 'Y' axis. From that graph the amount of sugar present in the sample was calculated.

3.7.3 Estimation of total free amino acids (TFAA)

The content of total free amino acids (TFAA) in dried powdered petal samples was estimated by the method described by Rosen (1957).

The amino acids are colourless ionic compounds that form the basic building blocks of proteins. Apart from being bound as proteins, amino acids also exist in the free form in many tissues and are known as free amino acids. They are mostly water soluble in nature. During senescence of cut rose cv. Dame de Coeur and Lady X, the free amino acid composition exhibited a change (Gao and Wu, 1990) and hence the measurement of the total free amino acids gives the physiological and health status of cut roses in the vase.

The principle behind the estimation of total free amino acids is that ninhydrin a powerful oxidizing agent, decarboxylates the alpha amino acids and yields an intensely coloured bluish purple product which is colorimetrically measured at 570 nm.

Ninhydrin + alpha acid = hydrindatin + decarboxylated amino acid + CO_2 + H_2O

Hydindatin + ninhydrin + ammonia = Purple coloured product + H_2O

Reagents used:

i. Stock NaCN of 0.01 M

490 mg per lit.

ii. Acetate buffer

2700 g NaOAC + 2 lit. H_2O + 500 ml glacial acetic acid, making up volume to 7.5 lit. with double distilled water. This buffer should be of pH 5.3 to 5.4.

iii. Acetate cyanide

0.0002 M NaCN in acetate buffer, 20 ml of solution (i) made to 1 lit. with solution (ii).

iv. Ninhydrin

3 per cent methyl cellulose (ethylene glycol mono ethylene ether).

v. Diluent

Isopropyl alcohol: water (1:1)

Procedure

Extraction of amino acids 100 mg of petal samples were weighed and ground in a pestle and mortar with 5 to 10 ml of 80 per cent ethanol. This was centrifuged twice and the supernatants were pooled.

Method To 1 ml of sample containing 0.02 to 0.04 μ mole of amino acid, 0.5 ml of cyanide buffer and 0.5 ml of ninhydrin reagent (in methyl cellulose) were added. This was heated in 100^0C boiling water bath for 10 to 12 minutes up to maximum colour development. Immediately after removing from water bath 5 ml of isopropyl alcohol + water diluent were added rapidly and shaken vigorously. This was allowed to come to room temperature and the colour was read in a spectrophotometer at 570 nm. All colours were stable, fading only 1 to 2 per cent in 24 hours.

Standard 50 mg of leucine was dissolved in 50 ml of double distilled water in a volumetric flask. 10 ml of this stock standard was diluted to 100 ml in another volumetric flask for working standard. A series of volumes from 0.1 to 1 ml (0.1, 0.2, 0.4, 0.6, 0.8, and 1.0 ml) of this standard solution gives a concentration of 10 µg to 100 µg. This was preceded that of sample and clear development was read in a spectrophotometer.

Result Standard graph was drawn using absorbance Vs concentration. The concentration of the total free amino acids in the samples was estimated from the standard plot and expressed as per cent equivalent of leucine.

4. RESULTS

The present investigation comprised of various experiments on influence of gamma irradiation, pulsing with sucrose, and cold storage on vase life and quality of cut roses. The manifesting response of these treatments was seen on respiration rate, total soluble sugars and total free amino acids in 'Golden Gate' cut rose. The results obtained from various experiments are described hereunder.

4.1 POSTHARVEST LIFE OF CUT ROSES AS INFLUENCED BY GAMMA IRRADIATION, PULSING, AND DRY COLD STORAGE

4.1.1 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Golden Gate

Data presented in Table 4.1.1 and Appendix 1 indicate that changes in fresh and dry weights after cold storage, on 3^{rd} day in vase, and on senescence day in vase, and vase lives varied significantly over control (water-treated). Gamma irradiation dose of 0.025 kGy was found better than 0.05 and 0.10 kGy in all these parameters. Maximum gain in fresh weights i.e. 1.42, 1.32, and 1.19 g after cold storage was recorded in seven days treatment with gamma rays 0.025, 0.05, and 0.10 kGy, respectively. Minimum loss in fresh weights i.e. -0.16, -0.18, and –0.21 g on senescence day in vase was recorded in three days treatment with gamma ray doses of 0.025, 0.05, and 0.10 kGy, respectively. Maximum loss in fresh weight (-2.21 g) on senescence day was in control. Corresponding changes in dry weights were also recorded in various treatments. Maximum vase lives of 12.00, 12.00, and 11.66 days were recorded in three day's treatment with gamma rays 0.025, 0.05, and 0.10 kGy, respectively. Minimum vase life was recorded in 12 day's treatment with all the three ^{60}Co doses. Vase life value for control was 8.00 days. Hence, it is concluded that cut flowers of 'Golden Gate' could be dry cold stored for seven days with gamma rays doses of 0.025, 0.05, and 0.10 kGy without affecting their vase life.

Table 4.1.1 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Golden Gate

Storage days	Changes in fresh weight (g)									Changes in dry weight (g)									Vase life (days)		
	After cold storage			On 3rd day in vase			On senescence day in vase			After cold storage			On 3rd day in vase			On senescence day in vase			0.025	0.05	0.10
	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10			
3	0.66	0.61	0.55	0.89	0.82	0.79	-0.16	-0.18	-0.21	0.15	0.14	0.12	0.19	0.21	0.20	-0.03	-0.05	-0.07	12.00	12.00	11.66
4	0.74	0.66	0.61	0.98	0.92	0.88	-0.47	-0.50	-0.55	0.16	0.16	0.13	0.20	0.19	0.18	-0.10	-0.10	-0.12	11.66	11.00	11.33
5	0.84	0.81	0.65	1.12	1.05	0.95	-0.52	-0.63	-0.72	0.18	0.17	0.15	0.23	0.22	0.19	-0.11	-0.13	-0.15	11.00	10.33	10.00
6	1.15	1.08	0.92	1.35	1.29	1.21	-0.69	-0.86	-0.91	0.24	0.22	0.19	0.29	0.27	0.25	-0.14	-0.18	-0.19	10.66	9.66	9.00
7	1.42	1.32	1.19	1.52	1.43	1.28	-0.85	-0.92	-0.95	0.30	0.27	0.25	0.31	0.30	0.26	-0.18	-0.19	-0.20	9.66	9.00	8.66
8	1.35	1.26	1.15	1.40	1.30	1.17	-1.05	-1.10	-1.17	0.28	0.26	0.24	0.30	0.27	0.25	-0.21	-0.23	-0.26	8.33	8.00	8.00
9	1.17	0.99	0.91	1.25	1.08	1.05	-1.21	-1.27	-1.31	0.25	0.21	0.19	0.26	0.22	0.21	-0.25	-0.27	-0.29	7.33	7.66	7.00
10	0.92	0.78	0.72	0.99	0.87	0.79	-1.49	-1.55	-1.63	0.19	0.16	0.15	0.20	0.18	0.16	-0.31	-0.32	-0.34	6.66	6.33	6.66
11	0.71	0.64	0.53	0.80	0.75	0.66	-1.62	-1.67	-1.73	0.15	0.13	0.11	0.17	0.16	0.14	-0.34	-035	-0.36	6.33	5.66	5.00
12	0.52	0.43	0.36	0.63	0.57	0.55	-1.87	-1.92	-1.99	0.11	0.09	0.06	0.13	0.12	0.11	-0.39	-0.40	-0.42	5.00	4.66	4.33
Control	-	-	-	0.62	0.62	0.62	-2.21	-2.21	-2.21	-	-	-	0.14	0.14	0.14	-0.46	-0.46	-0.46	8.00	8.00	8.00
SEm±	0.015	0.016	0.014	0.030	0.021	0.021	0.024	0.027	0.034	0.003	0.003	0.004	0.004	0.005	0.005	0.004	0.005	0.006	0.203	0.140	0.172
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
CD at 5%	0.045	0.047	0.042	0.087	0.062	0.062	0.071	0.078	0.098	0.010	0.007	0.011	0.011	0.013	0.015	0.012	0.017	0.018	0.593	0.408	0.560

- Indicates loss in fresh/dry weight over the fresh/dry weight at harvest
** = Highly significantly

Table 4.1.2 Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Golden Gate

Storage days	Changes in fresh weight (g)									Changes in dry weight (g)									Vase life (days)		
	After cold storage			On 3rd day in vase			On senescence day in vase			After cold storage			On 3rd day in vase			On senescence day in vase			0.20	0.40	0.60
	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60			
3	0.51	0.45	0.42	0.74	0.71	0.66	-0.27	-0.32	-0.38	0.12	0.10	0.09	0.17	0.16	0.15	-0.06	-0.07	-0.08	10.00	9.33	8.66
4	0.56	0.53	0.39	0.78	0.77	0.61	-0.61	-0.65	-0.72	0.13	0.11	0.08	0.16	0.15	0.13	-0.13	-0.13	-0.15	9.66	8.66	8.33
5	0.62	0.49	0.35	0.92	0.69	0.53	-0.77	-0.82	-0.96	0.14	0.10	0.07	0.19	0.14	0.11	-0.16	-0.17	-0.20	9.00	8.00	8.00
6	0.85	0.42	0.31	1.15	0.63	0.48	-0.99	-1.05	-1.12	0.18	0.09	0.06	0.24	0.13	0.10	-0.20	-0.22	-0.23	8.33	7.33	7.33
7	0.77	0.39	0.28	1.07	0.57	0.39	-1.07	-1.18	-1.27	0.16	0.08	0.06	0.22	0.11	0.08	-0.22	-0.24	-0.26	7.66	6.33	6.66
8	0.65	0.35	0.25	0.95	0.52	0.31	-1.25	-1.34	-1.50	0.13	0.07	0.05	0.20	0.10	0.06	-0.26	-0.28	-0.31	6.33	5.00	5.33
9	0.53	0.31	0.19	0.82	0.47	0.28	-1.42	-1.53	-1.68	0.11	0.06	0.04	0.17	0.09	0.05	-0.29	-0.32	-0.35	6.00	4.66	4.66
10	0.42	0.28	0.17	0.69	0.39	0.23	-1.74	-1.92	-2.04	0.09	0.05	0.03	0.14	0.08	0.05	-0.36	-0.40	-0.42	5.00	4.33	4.00
11	0.37	0.25	0.14	0.54	0.33	0.19	-1.85	-2.09	-2.23	0.08	0.05	0.02	0.11	0.06	0.04	-0.38	-0.43	-0.46	4.33	4.00	3.66
12	0.26	0.18	0.11	0.47	0.25	0.16	-2.08	-2.25	-2.39	0.05	0.03	0.02	0.09	0.05	0.03	-0.43	-0.47	-0.50	4.00	3.66	3.00
Control	-	-	-	0.62	0.62	0.62	-2.21	-2.21	-2.21	-	-	-	0.14	0.14	0.14	-0.46	-0.46	-0.46	8.00	8.00	8.00
SEm±	0.007	0.006	0.005	0.016	0.008	0.010	0.023	0.029	0.032	0.002	0.001	0.001	0.003	0.002	0.002	0.006	0.006	0.006	0.117	0.124	0.121
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	*	**	**	**	**	**	**
CD at 5%	0.026	0.018	0.013	0.045	0.022	0.029	0.068	0.085	0.072	0.005	0.004	0.003	0.008	0.005	0.005	0.017	0.017	0.016	0.348	0.361	0.353

- Indicates loss in fresh/dry weight over the fresh/dry weight at harvest
** = Highly significant
* = Significant

Table 4.1.3 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on flower quality of cut rose cv. Golden Gate (vase lives are given in Table 1)

Storage days	Flower diameter (cm)											
	At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
3	1.69	1.65	1.66	2.13	2.10	2.08	5.09	4.95	4.90	7.92	7.83	7.75
4	1.65	1.68	1.69	2.17	2.16	2.11	5.00	4.90	4.84	7.78	7.67	7.62
5	1.57	1.66	1.63	2.22	2.17	2.15	4.95	4.82	4.76	7.67	7.58	7.49
6	1.60	1.65	1.65	2.27	2.22	2.19	4.87	4.73	4.66	7.53	7.41	7.34
7	1.66	1.66	1.60	2.35	2.27	2.24	4.74	4.68	4.57	7.12	6.94	6.82
8	1.63	1.67	1.65	2.42	2.35	2.32	4.63	4.53	4.42	6.98	6.84	6.75
9	1.65	1.69	1.69	2.50	2.47	2.39	4.57	4.48	4.35	6.85	6.70	6.62
10	1.69	1.61	1.64	2.67	2.56	2.47	4.40	4.36	4.27	6.72	6.59	6.41
11	1.63	1.67	1.60	2.81	2.73	2.55	4.20	4.15	4.08	6.39	6.22	6.14
12	1.66	1.63	1.69	2.99	2.62	2.50	4.07	3.99	3.85	6.00	5.79	5.68
Control	1.65	1.65	1.65	-	-	-	4.47	4.47	4.47	7.02	7.02	7.02
SEm±	0.035	0.036	0.038	0.039	0.050	0.038	0.077	0.074	0.071	0.133	0.179	0.156
F test	NS	NS	NS	**	**	**	**	**	**	**	**	**
CD at 5%	-	-	-	0.114	0.145	0.111	0.225	0.216	0.265	0.387	0.523	0.455

NS = Non significant
** = Highly significant

4.1.2 Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Golden Gate

Changes in fresh and dry weights after cold storage, on 3rd day in vase, and on senescence day in vase, and vase lives varied significantly over control (Table 4.1.2 and Appendix 2). Gamma irradiation dose of 0.20 kGy was found better than 0.40 and 0.60 kGy in all these parameters. After cold storage, maximum gain in fresh weight (0.85 g) was recorded with gamma rays 0.20 kGy (dose) in six day's treatment. Maximum gain in fresh weight (0.53 g) after cold storage with ^{60}Co dose 0.40 kGy was recorded in four days treatment whereas after cold storage, maximum gain in fresh weight (0.42 g) with gamma rays dose of 0.60 kGy was recorded in three day's treatment. Similar changes on gain in fresh weights were also recorded on 3rd day in vase. On senescence day in vase, minimum loss in fresh weight was in three day's treatment with all the three ^{60}Co doses. Maximum loss in fresh weight (–2.39 g) on senescence day in vase was recorded with gamma rays 0.60 kGy dose) in 12 day's treatment. Loss in fresh weight on senescence day for control was –2.21 g. Corresponding changes in dry weights were also recorded but on senescence day in vase, with gamma rays dose of 0.60 kGy, dry weight change was non-significant. Maximum vase lives of 10.00, 9.33, and 8.66 days were recorded in three day's treatment with gamma rays doses of 0.20, 0.40, and 0.60 kGy, respectively. Minimum vase lives were recorded in 12 day's treatment with all the three doses. Vase life value for control was 8.00 days. Hence it is concluded that cut flowers of 'Golden Gate' after treating them with gamma rays dose 0.60 kGy could be dry cold stored for three days without affecting vase life over control. With irradiation dose of 0.40 kGy, cut flowers could be dry cold stored for four days and with 0.20 kGy for five days.

4.1.3 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on flower quality of cut rose cv. Golden Gate

Perusal of Table 4.1.3 and Appendix 3 indicates that flower diameter after cold storage, on 3rd day in vase, and on complete flower expansion varied significantly over control. Non-significant results were obtained on variations in flower diameter at harvest. Maximum flower diameter of 2.99 cm, after cold storage was recorded with gamma rays 0.025 kGy in 12 day's treatment. With gamma rays

e 4.1.4 Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and dry cold storage ($2^{0}C$) on flower quality of cut rose cv. Golden Gate (vase lives are given in Table 2)

Storage days	Flower diameter (cm)											
	At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
3	1.66	1.65	1.63	2.00	1.97	1.88	4.78	4.75	4.66	7.74	7.64	7.35
4	1.67	1.67	1.62	2.07	2.00	1.94	4.73	4.70	4.52	7.65	7.57	7.30
5	1.69	1.63	1.67	2.12	2.05	1.99	4.68	4.52	4.45	7.43	7.36	7.13
6	1.63	1.60	1.65	2.17	2.13	2.03	4.59	4.43	4.31	7.37	7.11	6.92
7	1.60	1.59	1.64	2.23	2.17	2.15	4.39	4.25	4.18	6.99	6.81	6.71
8	1.70	1.66	1.67	2.32	2.28	2.24	4.32	4.16	4.08	6.75	6.66	6.52
9	1.66	1.65	1.69	2.39	2.32	2.27	4.22	3.90	3.85	6.53	6.46	6.17
10	1.68	1.69	1.62	2.42	2.38	2.32	4.18	3.82	3.65	6.35	6.31	5.53
11	1.62	1.68	1.63	2.50	2.46	2.40	3.95	3.75	3.57	6.05	6.00	5.20
12	1.61	1.63	1.64	2.47	2.42	2.37	3.66	3.60	3.49	5.52	5.37	5.03
Control	1.65	1.65	1.65	-	-	-	4.47	4.47	4.47	7.02	7.02	7.02
SEm±	0.031	0.031	0.027	0.036	0.040	0.039	0.070	0.082	0.068	0.110	0.127	0.106
F test	NS	NS	NS	**	**	**	**	*	*	**	**	*
CD at 5%	-	-	-	0.105	0.117	0.113	0.205	0.220	0.187	0.320	0.376	0.308

NS = Non significant
** = Highly significant
* = Significant

0.05 kGy, maximum flower diameter of 2.73 cm after cold storage was recorded in 11 day's treatment. With gamma rays dose of 0.10 kGy, maximum flower diameter (2.55 cm) after cold storage was recorded in 11 day's treatment. Maximum flower diameter, on 3rd day in vase was recorded in three day's treatment irrespective of irradiation doses. Maximum flower diameter of 5.09 cm was recorded on 3rd day in vase was with gamma rays 0.025 kGy on three day's treatment. Flower diameter on 3rd day in vase for control was 4.47 cm. Significant variations in flower diameter on 3rd day in vase with ^{60}Co 0.025 kGy dose were obtained up to seven days treatments whereas with 0.05 and 0.10 kGy up to six and five day's treatments, respectively. Maximum flower diameter (7.92 cm), on complete flower opening was recorded with irradiation dose of 0.025 kGy in three day's treatment. Maximum flower diameters i.e. 7.83 and 7.75 cm, on complete flower expansion were recorded in three day's treatment with irradiation doses of 0.05 and 0.10 kGy, respectively. Flower diameter on complete flower expansion for control was 7.02 cm. Significant variations in flower diameter on complete flower expansion with irradiation dose of 0.025 kGy were obtained up to six day's treatments whereas with 0.05 and 0.10 kGy up to five day's treatments.

4.1.4 Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on flower quality of cut rose cv. Golden Gate

It is evident from Table 4.1.4 and Appendix 4 that flower diameter after cold storage, on 3rd day in vase, and on complete flower opening varied significantly over control. Non-significant results were obtained on flower diameter at harvest. Maximum flower diameter (2.50 cm) after cold storage was recorded with irradiation dose of 0.20 kGy in 11 day's treatment. After cold storage with gamma rays 0.40 and 0.60 kGy doses maximum flower diameters were obtained in 11 day's treatments. Maximum flower diameter of 4.78 cm on 3rd day in vase was recorded with ^{60}Co 0.20 kGy dose in three day's treatment. Maximum flower diameter (4.75 cm) with irradiation dose of 0.40 kGy on 3rd day in vase was obtained in three day's treatment. Maximum flower diameter of 4.66 cm on 3rd day in vase with irradiation dose 0.60 kGy was recorded in three day's treatment. Flower diameter on 3rd day in vase for control was 4.47 cm. Significant variations in flower diameter on 3rd in vase were recorded with gamma rays 0.20 kGy up to five day's treatments. Significant variations in flower diameter on 3rd day in vase with irradiation dose of 0.40 kGy were recorded

Table 4.1.5 Effect of gamma irradiations (0.025 and 0.05 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on water uptake of cut rose cv. Golden Gate (vase lives are given in Table1)

Storage days	Water uptake (ml) in days after keeping cut flowers in vase (water)																							
	1		2		3		4		5		6		7		8		9		10		11		12	
	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05
3	2.82	2.79	7.32	7.24	12.22	11.35	15.87	15.07	19.32	18.51	22.63	21.93	25.51	24.87	28.08	27.50	30.14	29.65	31.88	31.47	32.83	32.13	33.80	33.09
4	2.73	2.68	7.17	7.07	11.98	11.13	15.60	14.76	18.99	18.25	22.20	21.56	24.92	24.42	27.36	26.97	29.31	29.04	30.93	30.76	32.02	31.40	32.25	
5	2.65	2.59	7.02	6.91	11.74	10.87	15.30	14.42	18.61	17.79	21.72	21.02	24.34	23.76	26.65	26.23	28.48	28.20	29.97	29.86	31.05	29.99		
6	2.59	2.54	6.82	6.74	11.45	10.57	14.89	14.02	18.07	17.27	21.02	20.44	23.48	23.07	25.62	25.40	27.33	27.26	28.77	27.25	28.95			
7	2.52	2.43	6.68	6.58	11.15	10.26	14.37	13.72	17.44	16.89	20.27	19.70	22.58	22.29	24.55	24.40	26.15	26.13	26.27					
8	2.35	2.26	6.34	6.27	10.00	9.90	13.62	13.13	16.76	16.22	19.46	19.20	21.62	21.58	23.61	23.43		23.50						
9	2.23	2.12	6.15	5.92	9.85	9.62	13.16	12.66	15.98	15.63	18.52	18.40	20.49	20.23	20.42	20.28								
10	2.07	1.96	5.89	5.49	9.54	9.26	12.32	12.18	14.96	14.82	17.40	17.12	17.65	17.25										
11	1.95	1.84	5.60	5.09	8.89	8.87	11.45	11.40	14.42	13.75	17.10	13.92	17.40											
12	1.77	1.65	5.24	4.74	8.49	8.43	11.12	10.66	12.35	11.70														
Control	2.34	2.34	6.37	6.37	9.75	9.75	13.05	13.05	16.18	16.18	18.70	18.70	21.30	21.30	23.00	23.00								
SEm±	0.054	0.027	0.085	0.062	0.100	0.162	0.218	0.214	0.205	0.220	0.301	0.192	0.204	0.328	0.336	0.621	0.236	0.310	0.223	0.245	0.231	0.201		
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**		
CD at 5%	0.156	0.078	0.248	0.182	0.291	0.472	0.637	0.624	0.598	0.642	0.878	0.559	0.595	0.959	0.981	0.761	0.687	0.905	0.652	0.716	0.675	0.587		

** = Highly significant

Table 4.1.6 Effect of gamma irradiations (0.10 and 0.20 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on water uptake of cut rose cv. Golden Gate (vase lives are given in Tables 1 and 2)

Storage days	Water uptake (ml) in days after keeping cut flowers in vase (water)																							
	1		2		3		4		5		6		7		8		9		10		11		12	
	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20
3	2.74	2.69	7.14	7.01	11.05	10.83	14.60	14.32	17.97	17.62	21.09	20.64	23.86	23.36	26.35	25.74	28.20	27.51	29.83	29.06	30.84		30.90	
4	2.63	2.60	6.94	6.83	10.72	10.55	14.20	13.96	17.45	17.14	20.52	20.04	23.08	22.64	25.40	24.80	27.21	26.47	28.55	26.58	28.63			
5	2.55	2.55	6.82	6.71	10.34	10.23	13.74	13.76	17.06	16.92	19.95	19.48	22.64	22.14	24.35	23.74	25.84	24.82	27.05					
6	2.50	2.45	6.75	6.48	10.23	9.79	13.61	12.89	16.89	15.89	19.78	18.32	22.38	21.48	23.90	22.25	24.62	22.36						
7	2.46	2.18	6.70	6.15	10.18	9.17	13.46	12.03	16.80	14.74	19.50	17.18	22.20	19.98	23.73	19.05	24.82							
8	2.27	2.00	6.37	5.82	9.88	8.64	12.84	11.36	15.64	13.93	18.14	16.26	19.94	16.62	21.56									
9	1.96	1.79	5.85	5.35	8.91	7.90	12.24	10.62	14.77	13.02	17.08	15.14	18.58											
10	1.80	1.61	5.32	4.88	7.83	7.14	11.22	9.50	13.54	11.71	14.63		15.70											
11	1.63	1.44	4.78	4.42	7.13	6.49	9.42	8.77	11.88	8.84														
12	1.50	1.32	4.42	4.09	6.50	6.00	8.65	8.01	9.51															
Control	2.34	2.34	6.37	6.37	9.75	9.75	13.05	13.05	16.18	16.18	18.70	18.70	21.30	21.30	23.00	23.00								
SEm±	0.034	0.035	0.104	0.110	0.149	0.127	0.151	0.220	0.183	0.221	0.260	0.246	0.296	0.257	0.233	0.269	0.183	0.187	0.184					
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**					
CD at 5%	0.099	0.181	0.303	0.322	0.436	0.369	0.441	0.643	0.535	0.645	0.759	0.719	0.865	0.749	0.679	0.704	0.535	0.551	0.537					

** = Highly significant

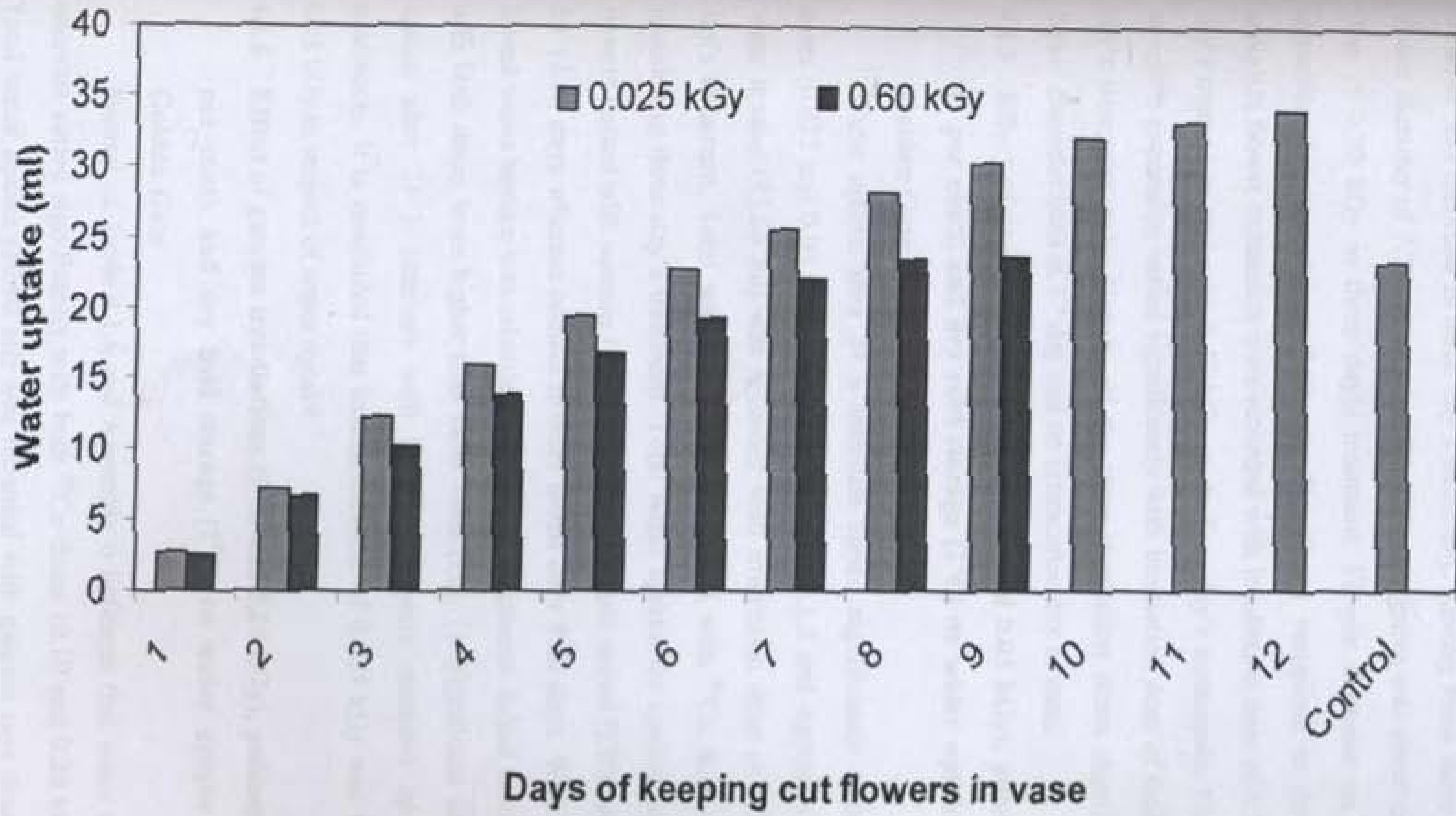

Fig. 1. Effect of gamma irradiation doses (0.025 and 0.60 kGy), pulsing with sucrose (3 %) and dry cold storage (2^0C) for three days on water uptake of cut rose cv. Golden Gate

up to four day's treatments whereas with 0.60 kGy in three day's treatment only. On complete flower opening, with all the three irradiation doses, maximum flower diameter was recorded in three day's treatment. Among these three doses, maximum flower diameter of 7.74 cm on complete flower opening was observed with irradiation dose of 0.20 kGy in three day's treatment. Flower diameter on complete flower expansion for control was 7.02 cm. Significant variations in flower diameter on complete flower expansion were recorded with irradiation dose of 0.20 kGy up to five day's treatments and with 0.40 kGy up to four day's treatments. Flower diameter on complete expansion varied significantly with irradiation dose of 0.60 kGy up to three day's treatment only. Hence, all the three-irradiation doses significantly improved flower diameter both at 3rd day and on senescence day in vase.

4.1.5 Effect of gamma irradiations (0.025 and 0.05 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on water uptake of cut rose cv. Golden Gate

Water uptake after 24 h intervals varied significantly with both irradiation doses (0.025 and 0.05 kGy) over control (Table 4.1.5 and Appendix 5). Highest total water uptake (33.80 ml) was recorded with irradiation dose of 0.025 kGy in three day's treatment. Total water uptake of 33.09 ml with ^{60}Co dose of 0.05 kGy was recorded in three day's treatment. Total water uptake for control was 23.00 ml. Cut flowers pulsed with sucrose (3 per cent) and dry cold stored (2^0C) lasted in vase water for 12.00 days whereas control flowers lasted only 8.00 days. With both ^{60}Co doses, lowest water uptake was recorded in 12 day's treatment. Initial rates of water uptake with both doses were higher than latter ones (Fig. 1). Significant variations in water uptake after 24 h intervals with both doses were recorded up to seven day's treatments. It is concluded that irradiation dose of 0.025 kGy was found better than 0.05 kGy in respect of water uptake.

4.1.6 Effect of gamma irradiations (0.10 and 0.20 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on water uptake of cut rose cv. Golden Gate

Perusal of Table 4.1.6 and Appendix 6 indicates that water uptake after 24 h intervals varied significantly with both ^{60}Co doses (0.10 and 0.20 kGy) over control. Total water uptake (30.90 ml) was recorded with gamma rays dose of 0.10 kGy in three day's treatment. With gamma irradiation dose (0.20 kGy), total water uptake of

Table 4.1.7 Effect of gamma irradiations (0.40 and 0.60 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on water uptake of cut rose cv. Golden Gate (vase lives are given in Table 2)

Storage days	Water uptake (ml) in days after keeping cut flowers in vase (water)																	
	1		2		3		4		5		6		7		8		9	
	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60
3	2.61	2.52	6.89	6.74	10.45	10.15	14.12	13.79	17.12	16.76	20.10	19.24	22.80	22.02	23.75	23.41	24.63	23.52
4	2.48	2.37	6.68	6.47	10.20	8.98	13.67	12.24	16.81	15.29	19.48	18.76	22.10	20.03	22.95	21.92	23.04	22.00
5	2.36	2.23	6.48	6.23	9.60	8.40	12.41	11.55	15.90	14.26	18.35	17.61	20.65	18.65	22.47	20.19		
6	2.27	2.14	6.24	5.99	8.96	8.04	11.90	11.00	14.42	13.55	17.62	15.71	19.64	17.48	19.75	17.56		
7	1.95	1.80	5.77	5.47	8.59	7.06	11.49	10.72	14.05	13.17	16.27	15.23	16.35	15.29				
8	1.86	1.62	5.57	5.12	8.15	7.49	10.85	10.03	13.29	12.26		12.32						
9	1.62	1.51	5.04	4.72	7.43	6.92	9.61	8.94	9.26	9.03								
10	1.52	1.42	4.67	4.37	6.77	6.23	8.84	7.98	8.96									
11	1.30	1.19	4.11	3.73	6.02	5.44	7.95	5.56										
12	1.12	0.97	3.74	3.32	5.49	3.97	5.57											
Control	2.34	2.34	6.37	6.37	9.75	9.75	13.05	13.05	16.18	16.18	18.70	18.70	21.30	21.30	23.00			
SEm±	0.032	0.030	0.090	0.086	0.136	0.120	0.172	0.190	0.200	0.163	0.214	0.164	0.237	0.221	0.235			
F test	**	**	**	**	**	*	**	*	**	*	**	*	**	*	*			
CD at 5%	0.073	0.087	0.263	0.252	0.386	0.350	0.503	0.555	0.583	0.477	0.623	0.479	0.692	0.646	0.685			

** = Highly significant
* = Significant

Table 4.1.8 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Mercedes

Storage days	Changes in fresh weight (g)									Changes in dry weight (g)									Vase life (days)		
	After cold storage			On 3rd day in vase			On senescence day in vase			After cold storage			On 3rd day in vase			On senescence day in vase			0.025	0.05	0.10
	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10			
3	0.49	0.46	0.40	0.80	0.77	0.74	-0.15	-0.18	-0.21	0.10	0.10	0.08	0.17	0.16	0.16	-0.03	-0.04	-0.04	10.00	10.00	9.66
4	0.58	0.53	0.47	0.87	0.82	0.78	-0.40	-0.45	-0.49	0.12	0.11	0.10	0.18	0.17	0.16	-0.08	-0.09	-0.10	10.00	9.66	9.33
5	0.70	0.64	0.57	0.96	0.89	0.80	-0.52	-0.58	-0.63	0.15	0.13	0.12	0.20	0.19	0.17	-0.11	-0.12	-0.13	9.66	9.33	9.00
6	1.03	0.97	0.89	1.15	1.11	1.05	-0.60	-0.67	-0.71	0.22	0.20	0.19	0.24	0.23	0.22	-0.13	-0.14	-0.15	9.33	9.00	8.66
7	1.25	1.18	0.85	1.37	1.30	0.95	-0.77	-0.86	-0.90	0.26	0.25	0.18	0.29	0.27	0.20	-0.16	-0.18	-0.19	8.66	8.66	8.00
8	0.95	0.89	0.70	1.12	1.06	0.86	-0.85	-0.89	-0.97	0.20	0.19	0.15	0.24	0.22	0.18	-0.18	-0.19	-0.21	8.00	7.66	7.33
9	0.82	0.75	0.61	0.96	0.88	0.77	-0.99	-1.05	-1.09	0.17	0.16	0.13	0.20	0.19	0.16	-0.21	-0.22	-0.23	7.66	7.33	7.00
10	0.61	0.57	0.53	0.79	0.70	0.69	-1.17	-1.24	-1.34	0.13	0.12	0.11	0.17	0.15	0.14	-0.25	-0.26	-0.28	6.00	6.00	5.66
11	0.53	0.45	0.42	0.65	0.59	0.59	-1.30	-1.42	-1.50	0.11	0.09	0.09	0.14	0.12	0.12	-0.27	-0.30	-0.32	5.66	5.33	5.00
12	0.45	0.43	0.36	0.61	0.54	0.50	-1.45	-1.53	-1.61	0.09	0.09	0.07	0.13	0.11	0.10	-0.31	-0.32	-0.34	5.00	5.00	4.66
Control	-	-	-	0.41	0.41	0.41	-2.00	-2.00	-2.00	-	-	-	0.09	0.09	0.09	-0.42	-0.42	-0.42	7.66	7.66	7.66
SEm±	0.014	0.014	0.012	0.021	0.019	0.014	0.024	0.014	0.022	0.003	0.003	0.002	0.003	0.003	0.003	0.004	0.004	0.005	0.153	0.124	0.123
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
CD at 5%	0.041	0.042	0.034	0.062	0.056	0.042	0.071	0.041	0.063	0.008	0.007	0.007	0.009	0.008	0.007	0.012	0.013	0.013	0.044	0.362	0.36

- Indicates loss in fresh/dry weight over the fresh/dry weight at harvest
**= Highly significant

29.06 ml was recorded in three day's treatment. With both these doses, lowest water uptake was recorded in 12 day's treatment. Total water uptake in control was 23.00 ml. With gamma rays 0.10 kGy dose, significant variations in water uptake were measured up to seven day's treatments whereas with 0.20 kGy up to five day's treatments. Decrease in water uptake was recorded as the cut flowers progressed towards senescence. It is conspicuous that gamma rays 0.10 kGy dose is better than 0.20 kGy in respect of water uptake.

4.1.7 Effect of gamma irradiations (0.40 and 0.60 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on water uptake of cut rose cv. Golden Gate

It is evident from Table 4.1.7 and Appendix 7 that water uptake after 24 h intervals varied significantly with irradiation doses of 0.40 and 0.60 kGy over control. Highest total water uptake (24.63 ml) was recorded with gamma rays dose of 0.40 kGy in three day's treatment. Highest total water uptake of 23.52 ml was recorded with ^{60}Co dose of 0.60 kGy in three day's treatment. Total water uptake value for control was 23.00 ml. With both gamma rays doses, lowest water uptake was recorded in 12 day's treatment. Initial rates of water uptake with both doses were higher than latter ones. Significant variations in water uptake with irradiation dose of 0.40 kGy were recorded up to four day's treatments whereas with 0.60 kGy in three days treatment only. Hence, it is concluded that gamma rays dose of 0.40 kGy is better than 0.60 kGy in respect of water uptake.

4.1.8 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Mercedes

Changes in fresh and dry weights after cold storage, on 3rd day in vase, and on senescence day in vase, and vase life varied significantly over control (Table 4.1.8 and Appendix 8). After cold storage, maximum gain in fresh weight was recorded with gamma rays dose of 0.025 kGy than 0.05 and 0.10 kGy. Maximum fresh weight gain after cold storage (1.25 g) was recorded with irradiation dose of 0.10 kGy in seven day's treatment whereas the minimum (0.36 g) with 0.10 kGy in 12 day's treatment. Gain in fresh weight in increasing order was noted up to seven day's treatments with irradiation dose of 0.10 kGy. On 3rd day in vase, gamma rays dose of 0.025 kGy was found better than 0.05 and 0.10 kGy in terms of gain in fresh weight.

Table 4.1.9 Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Mercedes

Storage days	Changes in fresh weight (g)									Changes in dry weight (g)									Vase life (days)		
	After cold storage			On 3rd day in vase			On senescence day in vase			After cold storage			On 3rd day in vase			On senescence day in vase			0.20	0.40	0.60
	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60			
3	0.36	0.32	0.29	0.71	0.65	0.61	-0.25	-0.27	-0.30	0.08	0.07	0.06	0.15	0.14	0.13	-0.05	-0.06	-0.06	9.00	8.66	8.00
4	0.42	0.40	0.27	0.70	0.72	0.55	-0.56	-0.59	-0.60	0.09	0.08	0.06	0.15	0.15	0.12	-0.12	-0.12	-0.13	8.66	8.33	7.66
5	0.50	0.38	0.24	0.77	0.68	0.50	-0.67	-0.71	-0.75	0.11	0.08	0.05	0.16	0.14	0.11	-0.14	-0.15	-0.16	8.33	8.00	7.33
6	0.48	0.35	0.20	0.66	0.64	0.47	-0.75	-0.79	-0.80	0.10	0.07	0.04	0.14	0.14	0.10	-0.16	-0.17	-0.17	8.00	7.66	7.00
7	0.42	0.31	0.18	0.61	0.60	0.42	-0.96	-1.03	-1.07	0.09	0.06	0.04	0.13	0.13	0.09	-0.20	-0.22	-0.23	7.66	7.33	6.66
8	0.39	0.21	0.16	0.55	0.52	0.38	-1.04	-1.09	-1.15	0.08	0.05	0.03	0.12	0.11	0.08	-0.22	-0.23	-0.24	7.00	6.66	6.33
9	0.35	0.21	0.14	0.49	0.46	0.34	-1.20	-1.26	-1.31	0.07	0.04	0.03	0.10	0.10	0.07	-0.25	-0.27	-0.28	6.66	6.00	5.66
10	0.32	0.17	0.13	0.46	0.40	0.30	-1.42	-1.48	-1.55	0.07	0.04	0.03	0.10	0.08	0.06	-0.30	-0.31	-0.33	5.00	4.66	4.33
11	0.29	0.15	0.10	0.40	0.34	0.27	-1.59	-1.66	-1.72	0.06	0.03	0.02	0.08	0.07	0.06	-0.34	-0.35	-0.36	4.66	4.33	4.00
12	0.27	0.13	0.07	0.36	0.31	0.24	-1.70	-1.77	-1.83	0.06	0.03	0.01	0.07	0.06	0.05	-0.36	-0.38	-0.39	4.33	4.00	3.66
Control	-	-	-	0.41	0.41	0.41	-2.00	-2.00	-2.50	-	-	-	0.09	0.09	0.09	-0.42	-0.42	-0.42	7.66	7.66	7.66
SEm±	0.006	0.005	0.003	0.009	0.008	0.008	0.023	0.020	0.021	0.002	0.001	0.001	0.001	0.002	0.010	0.004	0.004	0.004	0.143	0.109	0.103
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	*
CD at 5%	0.017	0.015	0.010	0.027	0.025	0.022	0.066	0.059	0.061	0.007	0.003	0.002	0.004	0.005	0.004	0.012	0.012	0.012	0.418	0.312	0.300

- Indicates loss in fresh/dry weight over the fresh/dry weight at harvest
** = Highly significant
* = Significant

On 3rd day in vase, maximum gain in fresh weight (1.37 g) was recorded with gamma rays 0.025 kGy in seven day's treatment whereas the minimum of 0.50 g with 0.10 kGy in 12 day's treatment. Gain in fresh weight in increasing order on 3rd day in vase was observed up to seven day's treatments with gamma rays doses of 0.025 and 0.05 kGy while up to six day's treatments with 0.10 kGy. Gain in fresh weight for control was 0.41 g. On senescence day in vase, minimum loss in fresh weight was observed with gamma rays dose of 0.025 kGy. Among the treatments, minimum loss in fresh weight (-0.15 g) on senescence day in vase was recorded with 0.025 kGy in three day's treatment whereas the maximum (-1.61 g) with 0.10 kGy in 12 day's treatment. Loss in fresh weight value for control was -2.00 g. Corresponding changes in dry weights at various stages were also recorded. Irrespective of treatments, maximum vase life was recorded in three day's treatment, whereas the minimum in 12 day's treatment. Maximum vase life was recorded with irradiation dose of 0.025 kGy whereas the minimum with 0.10 kGy. Maximum vase life of 10.00 days was noted with irradiation doses 0.025 and 0.05 kGy in three day's treatment whereas the minimum (4.66 days) with 0.10 kGy in 12 day's treatment. Vase life value for control flowers was 7.66 days. Significant variations in vase life were recorded with irradiation doses of 0.025 and 0.05 kGy up to seven day's treatments whereas up to six days with 0.10 kGy. Hence, it is concluded that cut flowers of 'Mercedes' after treatment with any one of ^{60}Co doses i.e. 0.025 or 0.05 kGy and pulsing with sucrose could be dry cold stored for seven days without affecting their vase life. With irradiation treatment of 0.10 kGy and pulsing with sucrose, cut flowers could be dry cold stored for six days without affecting their ultimate life in vase.

4.1.9 Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^{0}C) on changes in fresh and dry weights, and vase lives of cut rose cv. Mercedes

It is evident from Table 4.1.9 and Appendix 9 that changes in fresh and dry weights after cold storage, on 3rd day in vase, and on senescence day in vase, and vase life varied significantly with gamma rays doses of 0.20, 0.40, and 0.60 kGy over control. After cold storage, maximum gain in fresh weight was recorded with gamma rays dose of 0.20 kGy than 0.40 and 0.60 kGy. After cold storage, maximum gain in fresh weight (0.50 g) was recorded with gamma rays dose of 0.20 kGy in five day's treatment. Gain in fresh weight in increasing order after cold storage was noted up to

Table 4.1.10 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on flower quality of cut rose cv. Mercedes (vase lives are given in Table 8)

Storage days	Flower diameter (cm)											
	At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
3	1.41	1.38	1.38	1.99	1.97	1.94	4.86	4.83	4.79	7.45	7.41	7.37
4	1.42	1.40	1.41	2.05	2.01	1.98	4.74	4.70	4.65	7.28	7.22	7.18
5	1.37	1.42	1.39	2.11	2.07	2.03	4.61	4.55	4.47	7.12	7.05	6.95
6	1.40	1.40	1.40	2.17	2.11	2.06	4.45	4.39	4.36	6.96	6.94	6.87
7	1.38	1.41	1.42	2.25	2.18	2.13	4.39	4.35	4.29	6.89	6.90	6.73
8	1.41	1.42	1.41	2.32	2.25	2.22	4.34	4.27	4.23	6.82	6.75	6.66
9	1.39	1.37	1.37	2.39	2.32	2.28	4.28	4.22	4.17	6.75	6.68	6.59
10	1.42	1.39	1.40	2.47	2.40	2.36	4.23	4.17	4.13	6.70	6.64	6.53
11	1.38	1.38	1.39	2.54	2.49	2.43	4.19	4.15	4.09	6.66	6.59	6.49
12	1.39	1.39	1.41	2.50	2.45	2.40	4.15	4.11	4.07	6.57	6.52	6.45
Control	1.40	1.40	1.40	-	-	-	4.10	4.10	4.10	6.50	6.50	6.50
SEm±	0.023	0.026	0.058	0.041	0.032	0.033	0.083	0.082	0.067	0.129	0.128	0.120
F test	NS	NS	NS	**	**	**	**	**	**	**	**	**
CD at 5%	-	-	-	0.119	0.094	0.097	0.241	0.243	0.195	0.037	0.373	0.351

NS = Non significant
** = Highly significant

five, four, and three day's treatments with irradiation doses 0.20, 0.40, and 0.60 kGy, respectively. On 3rd day in vase, maximum fresh weight gain was recorded with irradiation dose of 0.025 kGy than 0.40 and 0.60 kGy. On 3rd day in vase, maximum gain in fresh weight (0.77 g) was recorded with 0.20 kGy in five day's treatment whereas the minimum (0.24 g) with 0.60 kGy in 12 day's treatment. Gain in fresh weight in increasing order on 3rd day in vase was recorded up to five, four, and three days treatments with irradiation doses of 0.20, 0.40, and 0.60 kGy, respectively. Minimum loss in fresh weight on senescence day in vase was recorded with 0.20 kGy whereas the maximum with 0.60 kGy. On senescence day in vase, minimum loss in fresh weight (-0.25 g) was recorded with 0.20 kGy in three day's treatment whereas the maximum (-1.83 g) in 12 day's treatment. Loss in fresh weight on senescence day in vase for control was -2.00 g. Corresponding changes in dry weights at various stages were also recorded. Among the three irradiation doses, 0.20 kGy was found better than 0.40 and 0.60 kGy in terms of extension in vase life. Maximum vase life of 9.00 days was recorded with 0.20 kGy in three day's treatment. Significant variations in vase lives were recorded up to five, four and three day's treatments with irradiation doses of 0.20, 0.40, and 0.60 kGy, respectively.

4.1.10 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on flower quality of cut rose cv. Mercedes

Perusal of Table 4.1.10 and Appendix 10 indicates that flower diameter after cold storage, on 3rd day in vase, and on complete flower opening varied significantly with irradiation doses of 0.025, 0.05, and 0.10 kGy over control. Non-significant variations were recorded in flower diameter at harvest. After cold storage, maximum flower diameter (2.54 cm) was recorded with gamma rays dose of 0.025 kGy in 11 day's treatment. Minimum flower diameter (1.94 cm) was recorded with irradiation dose of 0.10 kGy in three day's treatment. After cold storage, increase in flower diameter was noted up to 11 day's treatment. On 3rd day in vase, ^{60}Co 0.025 kGy dose was found better than 0.05 and 0.10 kGy in terms of flower expansion. With all the three doses, maximum flower diameter was recorded in three day's treatment whereas the minimum in 12 day's treatment. Flower diameter on 3rd day in vase for control was 4.10 cm. Significant variations in flower diameter on 3rd day in vase were recorded up to seven day's treatments with gamma rays doses of 0.025 and 0.05 kGy

Table 4.1.11 Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on flower quality of cut rose cv. Mercedes (vase lives are given in Table 9)

Storage days	Flower diameter (cm)											
	At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
3	1.40	1.41	1.40	1.90	1.84	1.79	4.70	4.64	4.61	7.32	7.26	7.15
4	1.39	1.39	1.41	1.92	1.86	1.83	4.63	4.55	4.50	7.08	7.20	7.06
5	1.38	1.40	1.39	1.97	1.91	1.90	4.42	4.30	4.27	6.90	6.80	6.80
6	1.42	1.42	1.38	1.99	1.95	1.93	4.30	4.28	4.20	6.82	6.75	6.69
7	1.41	1.38	1.42	2.04	1.99	1.96	4.23	4.19	4.12	6.74	6.67	6.57
8	1.39	1.41	1.37	2.14	2.09	2.04	4.18	4.15	4.06	6.66	6.56	6.48
9	1.37	1.37	1.39	2.20	2.15	2.11	4.12	4.09	3.98	6.58	6.49	6.40
10	1.42	1.39	1.40	2.29	2.27	2.18	4.09	4.06	3.95	6.50	6.40	6.31
11	1.41	1.42	1.41	2.38	2.35	2.29	4.05	4.01	3.90	6.44	6.37	6.27
12	1.39	1.41	1.39	2.36	3.32	2.25	4.02	3.97	3.84	6.39	6.33	6.24
Control	1.40	1.40	1.40	-	-	-	4.10	4.10	4.10	6.50	6.50	6.50
SEm±	0.026	0.022	0.026	0.034	0.030	0.032	0.067	0.079	0.068	0.126	0.108	0.103
F test	NS	NS	NS	**	**	**	**	**	**	**	**	**
CD at 5%	-	-	-	0.098	0.088	0.094	0.201	0.023	0.197	0.360	0.315	0.300

NS = Non significant
** = Highly significant

and up to six days with 0.10 kGy. On complete flower opening, gamma rays dose of 0.025 kGy was found better than 0.05 and 0.10 kGy in increasing flower diameter. With all the three gamma rays doses, maximum flower opening was observed in three days treatment whereas the minimum in 11 day's treatment. On complete flower expansion, maximum flower diameter (7.45 cm) was recorded with gamma rays dose of 0.025 kGy in three day's treatment whereas the minimum (6.45 cm) with 0.10 kGy in 12 day's treatment. Significant variations in flower diameter on complete flower expansion were recorded up to seven day's treatments with gamma rays doses of 0.025 and 0.05 kGy and up to six day's treatments with 0.10 kGy. Hence, gamma rays dose of 0.025 kGy was found best for increasing flower diameter.

4.1.11 Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on flower quality of cut rose cv. Mercedes

Table 4.1.11 and Appendix 11 indicate that flower diameter after cold storage, on 3rd day in vase, and on complete flower opening varied significantly with gamma rays doses of 0.20, 0.40, and 0.60 kGy over control. At harvest, non-significant variations in flower diameter were recorded. After cold storage, gamma rays dose of 0.20 kGy was found better than 0.40 and 0.60 kGy for increasing flower diameter. After cold storage, maximum flower diameter (2.38 cm) was recorded with gamma rays dose of 0.20 kGy in 11 day's treatment whereas the minimum of 1.79 cm with 0.60 kGy in three day's treatment. Increase in flower diameter during cold storage with all the three doses was observed up to 11 day's treatment. On 3rd day in vase, maximum flower expansion was noted with gamma rays dose of 0.20 kGy whereas the minimum with 0.60 kGy. On 3rd day in vase, maximum flower expansion of 4.70 cm was observed with irradiation dose of 0.20 kGy in three day's treatment whereas the minimum of 3.84 cm with 0.60 kGy in 12 day's treatment. Flower diameter on 3rd day in vase for control was 4.10 cm. Significant variations in flower diameter on 3rd day in vase were recorded up to five days treatments with gamma rays doses of 0.20 and 0.40 kGy and up to four days with 0.60 kGy. On complete flower expansion, gamma rays dose of 0.20 kGy was found better than 0.40 and 0.60 kGy for increasing flower diameter. On complete flower opening, maximum flower diameter of 7.32 cm was recorded with gamma rays dose of 0.20 kGy in three day's treatment whereas the minimum of 6.24 cm with 0.60 kGy in 12 day's treatment. Flower diameter on

Table 4.1.12 Effect of gamma irradiations (0.025 and 0.05 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on water uptake of cv. Mercedes (vase lives are given in Table 8)

Storage days	Water uptake (ml) in days after keeping cut flowers in vase (water)																			
	1		2		3		4		5		6		7		8		9		10	
	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05
3	2.69	2.66	7.15	7.12	12.03	11.96	15.60	15.53	19.10	19.03	22.35	22.28	25.36	25.27	27.80	25.96	29.81	27.69	30.09	28.90
4	2.58	2.55	7.00	6.97	11.71	11.60	15.32	15.25	18.64	18.55	21.81	21.74	24.70	24.60	26.62	25.42	28.05	26.85	28.47	27.05
5	2.40	2.47	6.76	6.70	10.78	10.65	14.94	14.83	17.22	17.15	20.40	20.31	23.61	23.40	24.16	24.15	25.70	25.17	26.10	25.38
6	2.25	2.40	6.51	6.61	10.20	10.30	14.12	14.21	16.53	16.83	19.67	19.55	21.72	22.76	22.25	23.42	23.58	23.69	24.02	
7	2.16	2.36	6.50	6.65	10.08	10.15	13.51	13.50	16.77	16.75	19.54	19.40	22.10	22.50	22.53	22.25	22.77	23.27		
8	1.98	1.93	6.20	6.25	9.70	8.12	13.02	9.65	15.60	13.90	18.21	16.42	19.03	19.07	19.29	19.25				
9	1.83	1.75	5.98	5.92	9.51	7.90	12.60	9.42	13.12	12.45	13.40	12.96	13.82	13.26	14.06	13.57				
10	1.72	1.65	5.52	5.45	9.12	7.40	12.35	8.96	13.07	12.21	13.36	12.52								
11	1.65	1.57	5.17	5.12	8.56	7.07	11.21	8.26	11.59	9.05	11.82	9.29								
12	1.57	1.50	4.98	4.90	8.20	6.62	10.85	7.35	11.07	7.66										
Control	2.01	2.01	6.13	6.13	9.50	9.50	12.81	12.81	15.75	15.75	18.40	18.40	21.00	21.00	21.27	21.27				
SEm±	0.040	0.034	0.116	0.120	0.193	0.216	0.214	0.234	0.244	0.237	0.326	0.268	0.292	0.230	0.238	0.301	0.220	0.320	0.269	0.264
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
CD at 5%	0.117	0.100	0.338	0.349	0.562	0.631	0.626	0.604	0.711	0.693	0.951	0.782	0.853	0.670	0.695	0.879	0.642	0.934	0.794	0.770

** = Highly significant

Table 4.1.13 Effect of gamma irradiations (0.10 and 0.20 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on water uptake of cut rose cv. Mercedes (vase lives are given in Tables 8 and 9)

Storage days	Water uptake (ml) in days after keeping cut flowers in vase (water)																		
	1		2		3		4		5		6		7		8		9		10
	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10
3	2.61	2.53	7.04	7.00	11.88	11.72	15.45	15.30	18.96	22.02	22.18	22.02	25.20	23.70	25.59	24.99	25.95	25.25	26.17
4	2.49	2.41	6.90	6.77	11.51	11.55	15.17	15.01	18.46	21.51	21.69	21.51	24.54	22.63	24.90	23.90	25.20	24.33	25.45
5	2.31	2.36	6.64	6.50	10.53	10.17	14.75	13.60	17.07	19.28	20.24	21.25	23.21	22.01	23.74	23.75	24.09	24.05	
6	2.22	2.08	6.60	6.31	10.10	9.62	13.41	12.60	16.60	16.80	19.35	16.80	22.06	17.36	23.10	17.69	23.42		
7	2.01	1.94	6.30	6.34	9.87	9.10	13.31	11.53	16.45	15.11	19.13	15.11	21.76	15.48	22.06	15.82			
8	1.87	1.86	6.19	6.07	8.06	8.56	9.55	10.71	13.81	14.27	16.30	14.27	18.53	14.60	19.05				
9	1.71	1.65	5.85	5.70	7.81	7.80	9.32	9.33	11.55	13.17	12.13	13.38	12.58	13.38					
10	1.60	1.56	5.38	5.23	7.28	7.53	8.81	8.77	9.25		9.66								
11	1.51	1.47	5.02	4.15	7.23	6.57	7.92	7.26	8.35										
12	1.46	1.40	4.79	3.90	6.55	6.12	7.23	7.08	7.69										
Control	2.01	2.01	6.13	6.13	9.50	9.50	12.81	12.81	15.75	18.40	18.40	21.00	21.00	21.00	21.27	21.27			
SEm±	0.032	0.033	0.076	0.093	0.145	0.145	0.187	0.183	0.272	0.284	0.265	0.258	0.348	0.258	0.283	0.261	0.279	0.189	
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	
CD at 5%	0.094	0.096	0.221	0.272	0.423	0.423	0.547	0.535	0.794	0.827	0.775	0.754	1.015	0.754	0.826	0.762	0.815	0.552	

** = Highly significant

complete flower expansion for control was 6.50 cm. Significant variations in flower diameter on complete opening were recorded up to five day's treatments with irradiation doses of 0.20 and 0.40 kGy and up to four days with 0.60 kGy. Hence, it is concluded that gamma rays dose of 0.20 kGy is best in increasing flower diameter at various stages of postharvest life of cut 'Mercedes' flowers.

4.1.12 Effect of gamma irradiations (0.025 and 0.05 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on water uptake of cut rose cv. Mercedes

Water uptake at 24 h intervals varied significantly with gamma rays doses of 0.025 and 0.05 kGy over control (Table 4.1.12 and Appendix 12). Gamma rays dose of 0.025 kGy was found better than 0.05 kGy for water uptake on different days. Highest total water uptake (30.09 ml) was recorded with irradiation dose of 0.025 kGy in three day's treatment whereas the lowest of 7.66 ml with 0.05 kGy in 12 day's treatment. Total water uptake value for control was 21.27 ml. With both doses, highest total water uptake was recorded in three day's treatment, whereas the lowest in 12 day's treatment. Initial rates of water uptake were higher than the latter ones. Significant variations in water uptake on different days with both doses were recorded up to seven days treatment. Hence, it is concluded that the increased water uptake with irradiation dose of 0.025 kGy manifested the enhanced vase life of cut 'Mercedes' flowers.

4.1.13 Effect of gamma irradiations (0.10 and 0.20 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on water uptake of cut rose cv. Mercedes

Perusal of Table 4.1.13 and Appendix 13 reveals that water uptake at 24 h intervals varied significantly with gamma irradiation doses of 0.10 and 0.20 kGy over control. Highest total water uptake was recorded in three day's treatment whereas the lowest in 12 day's treatment. Gamma irradiation dose of 0.10 kGy was found better in respect of water uptake at different days than 0.20 kGy. Highest total water uptake of 26.17 ml was recorded with gamma rays dose of 0.10 kGy in three day's treatment whereas the lowest (7.08 ml) with 0.20 kGy in 12 day's treatment. Total water uptake for control was 21.27 ml. Decrease in water uptake was recorded with increase in storage period. As cut flowers progressed towards senescence, decreasing rate of water uptake was observed. Significant variations in water uptake up to six and five

Table 4.1.14 Effect of gamma irradiations (0.40 and 0.60 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on water uptake of cut rose cv. Mercedes (vase lives are given in Table 9)

Storage days	Water uptake (ml) in days after keeping cut flowers in vase (water)																	
	1		2		3		4		5		6		7		8		9	
	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60
3	2.45	2.36	6.95	6.52	11.62	9.97	15.17	13.50	18.70	16.65	21.90	19.15	23.62	21.89	24.85	22.16	25.06	
4	2.25	2.14	6.58	6.30	10.10	9.51	13.50	13.12	16.55	16.07	19.31	18.75	21.90	19.52	23.16	19.74	23.34	
5	2.10	2.07	6.35	5.92	9.91	9.05	13.27	12.85	13.48	13.30	16.31	16.17	18.02	17.81	18.43	18.12		
6	2.18	2.00	6.20	5.20	9.50	8.61	12.42	12.13	13.16	12.85	14.05	13.71	14.82	14.30	15.17			
7	2.12	1.63	5.92	4.91	8.42	8.12	10.62	10.35	12.50	12.26	13.07	12.78	13.86	13.14	14.20			
8	1.59	1.42	5.80	4.62	8.47	7.09	10.70	9.32	11.45	10.42	11.99	10.96	12.28					
9	1.47	1.32	5.63	4.35	7.95	6.72	9.83	7.86	10.82	8.40	11.20	8.75						
10	1.39	1.21	5.10	4.06	7.22	6.88	8.35	7.87	8.81	8.11								
11	1.35	1.05	4.56	3.53	7.05	4.85	8.09	5.17	8.36									
12	1.30	0.99	3.70	3.41	5.03	4.66	5.60	5.19										
Control	2.01	2.01	6.13	6.13	9.50	9.50	12.81	12.81	15.75	15.75	18.40	18.40	21.00	21.00	21.27	21.27		
SEm±	0.038	0.058	0.093	0.081	0.147	0.148	0.210	0.196	0.237	0.183	0.219	0.209	0.238	0.212	0.232	0.129		
F test	**	**	**	**	**	*	**	*	**	**	**	*	**	**	**	**		
CD at 5%	0.105	0.163	0.270	0.237	0.428	0.433	0.613	0.573	0.693	0.533	0.639	0.610	0.694	0.619	0.677	0.380		

** = Highly significant
* = Significant

Table 4.1.15 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Noblesse

Storage days	Changes in fresh weight (g)									Changes in dry weight (g)									Vase life (days)		
	After cold storage			On 3rd day in vase			On senescence day in vase			After cold storage			On 3rd day in vase			On senescence day in vase			0.025	0.05	0.10
	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10			
3	0.57	0.53	0.49	0.81	0.75	0.71	-0.14	-0.17	-0.20	0.12	0.11	0.10	0.17	0.16	0.15	-0.03	-0.03	-0.04	11.66	11.66	11.00
4	0.66	0.57	0.55	0.88	0.84	0.76	-0.46	-0.49	-0.55	0.14	0.12	0.12	0.19	0.18	0.16	-0.10	-0.10	-0.12	11.00	10.66	10.33
5	0.75	0.71	0.62	1.01	0.98	0.84	-0.53	-0.62	-0.68	0.16	0.15	0.13	0.21	0.21	0.18	-0.11	-0.13	-0.14	10.66	10.33	9.66
6	1.10	1.05	0.86	1.28	1.20	1.10	-0.67	-0.86	-0.92	0.23	0.22	0.18	0.27	0.25	0.23	-0.14	-0.18	-0.19	10.00	9.66	9.00
7	0.98	0.90	0.73	1.20	1.09	0.98	-0.76	-0.95	-1.12	0.21	0.19	0.15	0.25	0.23	0.21	-0.16	-0.20	-0.24	8.66	8.33	8.00
8	0.86	0.76	0.64	1.08	0.96	0.86	-0.90	-1.17	-1.26	0.18	0.16	0.13	0.23	0.20	0.18	-0.19	-0.25	-0.27	8.33	8.00	7.66
9	0.74	0.60	0.52	0.95	0.84	0.74	-1.05	-1.29	-1.41	0.16	0.13	0.11	0.20	0.18	0.16	-0.22	-0.27	-0.30	8.00	7.66	6.33
10	0.63	0.52	0.41	0.83	0.70	0.62	-1.22	-1.46	-1.59	0.13	0.11	0.09	0.17	0.15	0.13	-0.26	-0.31	-0.34	7.33	7.00	5.66
11	0.52	0.38	0.34	0.64	0.59	0.50	-1.37	-1.62	-1.73	0.11	0.08	0.07	0.14	0.12	0.10	-0.29	-0.34	-0.37	6.66	6.00	5.00
12	0.39	0.32	0.27	0.50	0.45	0.41	-1.49	-1.73	-1.95	0.08	0.07	0.06	0.11	0.09	0.08	-0.32	-0.37	-0.41	5.00	4.66	4.33
Control	-	-	-	0.46	0.46	0.46	-2.05	-2.05	-2.05	-	-	-	0.10	0.10	0.10	-0.43	-0.43	-0.43	8.33	8.33	8.33
SEm±	0.016	0.010	0.009	0.017	0.013	0.120	0.020	0.020	0.025	0.003	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.005	0.168	0.107	0.127
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
CD at 5%	0.046	0.029	0.025	0.054	0.038	0.035	0.060	0.058	0.074	0.008	0.007	0.005	0.009	0.008	0.009	0.013	0.012	0.013	0.471	0.313	0.370

- Indicates loss in fresh/dry weight over the fresh/dry weight at harvest
** = Highly significant

day's treatments were recorded with irradiation doses of 0.10 and 0.20 kGy, respectively. Increased water uptake at 24 h intervals with irradiation dose 0.10 kGy resulted in enhanced vase life and quality of flowers in vase water.

4.1.14 Effect of gamma irradiations (0.40 and 0.60 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on water uptake of cut rose cv. Mercedes

It can be seen from Table 4.1.14 and Appendix 14 that water uptake at 24 h intervals varied significantly with gamma irradiation doses of 0.40 and 0.60 kGy over control. Highest total water uptake was recorded in three day's treatment whereas the lowest in 12 day's treatment. Gamma irradiation dose of 0.40 kGy was found better than 0.60 kGy in terms of water uptake on different days. Highest total water uptake (25.06 ml) was recorded with gamma rays 0.40 kGy in three day's treatment whereas the lowest (5.19 ml) with irradiation dose of 0.60 kGy in 12 day's treatment. Decrease in water uptake was observed with increase in storage duration. Moreover, initial rates of water uptake were higher than latter ones. Total water uptake value for control was 21.27 ml. Significant variations in water uptake were recorded up to four and three day's treatments with irradiation doses 0.40 and 0.60 kGy, respectively. Increased water uptake with ^{60}Co 0.40 kGy resulted in enhanced vase life than 0.60 kGy.

4.1.15 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Noblesse

Perusal of Table 4.1.15 and Appendix 15 indicates that changes in fresh and dry weights after cold storage, on 3rd day in vase, and on senescence day in vase, and vase life varied significantly over control. Among the three-irradiation doses of 0.025, 0.05, and 0.10 kGy, maximum gain in fresh weight after cold storage was recorded with 0.025 kGy. With ^{60}Co dose of 0.025 kGy after cold storage, maximum gain in fresh weight (1.10 g) was recorded in six day's treatment whereas the minimum (0.39 g) in 12 day's treatment. Similar trend was observed with irradiation doses of 0.05 and 0.10 kGy. On 3rd day in vase, irradiation dose of 0.025 kGy was found better than 0.05 and 0.10 kGy. With ^{60}Co dose of 0.025 kGy on 3rd day in vase, maximum gain in fresh weight (1.20 g) was recorded in six day's treatment whereas minimum of 0.45 g in 12 day's treatment. On 3rd day in vase, similar trend was observed with irradiation doses of 0.05 and 0.10 kGy. On 3rd day in vase, the gain in fresh weight value for

Table 4.1.16 Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Noblesse

Storage days	Changes in fresh weight (g)									Changes in dry weight (g)									Vase life (days)		
	After cold storage			On 3rd day in vase			On senescence day in vase			After cold storage			On 3rd day in vase			On senescence day in vase			0.20	0.40	0.60
	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60			
3	0.45	0.42	0.39	0.69	0.65	0.60	-0.23	-0.25	-0.27	0.09	0.10	0.08	0.14	0.14	0.13	-0.05	-0.05	-0.06	9.66	9.00	8.66
4	0.50	0.48	0.36	0.73	0.70	0.57	-0.58	-0.61	-0.65	0.11	0.10	0.08	0.15	0.15	0.12	-0.12	-0.13	-0.14	9.00	8.33	8.00
5	0.59	0.41	0.32	0.82	0.64	0.52	-0.71	-0.75	-0.78	0.12	0.09	0.07	0.17	0.14	0.11	-0.15	-0.16	-0.16	8.66	7.66	7.66
6	0.52	0.36	0.28	0.74	0.58	0.48	-0.95	-0.97	-1.03	0.11	0.07	0.06	0.16	0.12	0.10	-0.20	-0.20	-0.22	8.33	7.33	7.00
7	0.46	0.29	0.23	0.65	0.54	0.43	-1.16	-1.19	-1.24	0.10	0.06	0.05	0.14	0.11	0.09	-0.25	-0.26	-0.26	7.33	6.00	6.33
8	0.38	0.24	0.19	0.60	0.49	0.39	-1.32	-1.36	-1.41	0.08	0.05	0.04	0.13	0.10	0.08	-0.28	-0.29	0.30	6.00	4.66	5.00
9	0.33	0.20	0.15	0.52	0.44	0.36	-1.46	-1.51	-1.56	0.07	0.04	0.03	0.11	0.09	0.07	-0.31	-0.32	-0.33	5.66	4.33	4.33
10	0.25	0.17	0.12	0.48	0.40	0.33	-1.66	-1.72	-1.77	0.05	0.04	0.02	0.10	0.08	0.07	-0.35	-0.37	-0.37	5.00	4.00	4.00
11	0.21	0.15	0.10	0.41	0.38	0.30	-1.79	-1.85	-1.93	0.05	0.03	0.02	0.09	0.08	0.06	-0.38	-0.39	-0.41	4.33	4.00	3.66
12	0.18	0.13	0.08	0.39	0.36	0.28	-1.86	-1.91	-1.99	0.04	0.03	0.02	0.08	0.07	0.06	-0.39	-0.41	-0.42	4.00	3.66	3.33
Control	-	-	-	0.46	0.46	0.46	-2.05	-2.05	-2.05	-	-	-	0.10	0.10	0.10	-0.43	-0.43	-0.43	8.33	8.33	8.33
SEm±	0.006	0.005	0.005	0.010	0.006	0.007	0.021	0.023	0.031	0.002	0.001	0.001	0.002	0.002	0.001	0.006	0.004	0.005	0.114	0.120	0.181
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	*
CD at 5%	0.018	0.014	0.014	0.028	0.019	0.021	0.063	0.067	0.070	0.004	0.003	0.002	0.006	0.005	0.004	0.016	0.013	0.015	0.331	0.351	0.294

- Indicates loss in fresh/dry weight over the fresh/dry weight at harvest
** = Highly significant
* = Significant

control was 0.14 g. On senescence day in vase, maximum loss in fresh weight (–2.05 g) was noted in control. Minimum loss in fresh weight on senescence day in vase was recorded with irradiation dose of 0.025 kGy than 0.05 and 0.10 kGy. With ^{60}Co dose of 0.025 kGy on senescence day in vase minimum loss in fresh weight (–0.14 g) was observed in three day's treatment whereas the maximum (–1.49 g) in 12 day's treatment. Similar trend was observed on changes in dry weights after cold storage, on 3rd day in vase and on senescence day. With respect to vase life, irradiation dose of 0.025 kGy was found better than 0.05 and 0.10 kGy. Maximum vase life of 11.66 days was recorded with irradiation doses 0.025 and 0.05 kGy in three day's treatment. Minimum vase lives of 5.00, 4.66, and 4.33 days were observed in 12 day's treatment with irradiation doses of 0.025, 0.05, and 0.10 kGy, respectively. With all the three aforementioned doses, vase life varied significantly up to six day's treatments. Hence, it is concluded that cut flowers of 'Noblesse' could be dry cold stored (subjected to prior treatments of gamma irradiation and pulsing) for six days without affecting subsequent life in vase water.

4.1.16 Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Noblesse

It is clear from Table 4.1.16 and Appendix 16 that changes in fresh and dry weights after cold storage, on 3rd day in vase, and on senescence day in vase, and vase life varied significantly over control. Gamma irradiation of 0.20 kGy was found better for all these parameters than 0.40 and 0.60 kGy. With ^{60}Co 0.20 kGy dose after cold storage maximum gain in fresh weight (0.59 g) was recorded in five day's treatment whereas the minimum (0.18 g) in 12 day's treatment. With ^{60}Co dose of 0.40 kGy, after cold storage, maximum gain in fresh weight (0.48 g) was recorded in three day's treatment whereas the minimum (0.13 g) in 12 day's treatment. With ^{60}Co 0.60 kGy, after cold storage, maximum gain in fresh weight (0.39 g) was recorded in three day's treatment whereas the minimum (0.08 g) in 12 day's treatment. On 3rd day in vase, significant variations on gain in fresh weights were recorded up to nine, eight, and five day's treatments with irradiation doses of 0.20, 0.40, and 0.60 kGy, respectively. With ^{60}Co dose of 0.20 kGy, on 3rd day in vase, maximum gain in fresh weight (0.82 g) was observed in four day's treatment whereas the minimum (0.39 g) in 12 day's treatment. With ^{60}Co dose of 0.40 kGy, on 3rd day in vase, maximum gain in fresh

Table 4.1.17 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on flower quality of cut rose cv. Noblesse (vase lives are given in Table 15)

Storage days	Flower diameter (cm)											
	At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
3	1.60	1.59	1.55	2.07	2.04	2.01	5.02	5.00	4.88	7.80	7.74	7.70
4	1.57	1.58	1.57	2.11	2.09	2.05	4.94	4.92	4.78	7.71	7.65	7.55
5	1.59	1.62	1.61	2.16	2.13	2.09	4.85	4.80	4.70	7.59	7.54	7.46
6	1.61	1.55	1.56	2.20	2.15	2.11	4.72	4.68	4.66	7.36	7.35	7.31
7	1.54	1.57	1.58	2.28	2.20	2.15	4.54	4.45	4.35	7.20	7.14	7.00
8	1.57	1.56	1.61	2.37	2.26	2.20	4.41	4.32	4.20	6.97	6.82	6.68
9	1.59	1.63	1.62	2.44	2.37	2.29	4.28	4.16	4.05	6.72	6.57	6.30
10	1.58	1.55	1.55	2.56	2.48	2.39	4.17	4.04	3.96	6.18	6.20	6.02
11	1.60	1.56	1.54	2.85	2.52	2.47	4.09	3.98	3.85	5.99	5.93	5.83
12	1.56	1.57	1.58	2.71	2.40	2.36	4.00	3.92	3.79	5.90	5.75	5.61
Control	1.58	1.58	1.58	-	-	-	4.25	4.25	4.25	6.85	6.85	6.85
SEm±	0.028	0.025	0.026	0.043	0.034	0.032	0.084	0.083	0.083	0.113	0.129	0.112
F test	NS	NS	NS	**	**	**	**	**	**	**	**	**
CD at 5%	-	-	-	0.125	0.099	0.093	0.246	0.242	0.243	0.330	0.377	0.326

NS = Non significant
** = Highly significant

weight (0.70 g) was recorded in four day's treatment whereas the minimum (0.36 g) in 12 day's treatment. With irradiation dose of 0.60 kGy, on 3rd day in vase, maximum gain in fresh weight (0.60 g) was recorded in three day's treatment whereas the minimum (0.28 g) in 12 day's treatment. Gain in fresh weight on 3rd day in vase, value for control was 0.46 g. Among the treatments, maximum loss in fresh weights on senescence day in vase were recorded in 12 day's treatment whereas the minimum in three day's treatment. Maximum value for loss in fresh weight (–2.05 g) was recorded in control. Corresponding changes in dry weights were also recorded after cold storage, on 3rd day in vase and on senescence day in vase. With respect to vase lives, ^{60}Co 0.20 kGy was found better than 0.40 and 0.60 kGy. With irradiation dose 0.20 kGy, maximum vase life of 9.66 days was noted in three day's treatment whereas the minimum (4.00 days) in 12 day's treatment. With this dose significant variation in vase life was recorded up to five day's treatments. With ^{60}Co dose of 0.40 kGy, maximum vase life of 9.00 days was recorded in three day's treatment whereas the minimum (3.66 days) in 12 day's treatment. With this dose, significant variations in vase life were observed in three day's treatment only. With ^{60}Co dose of 0.60 kGy, maximum vase life of 8.66 days was recorded in three day's treatment while the minimum (3.00 days) in 12 day's treatment. Significant variations in vase life with ^{60}Co dose of 0.60 kGy were recorded in three day's treatment only. Vase life value for control was 8.33 days. Hence, it is concluded that gamma irradiation dose of 0.20 kGy is better than 0.40 and 0.60 kGy.

4.1.17 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on flower quality of cut rose cv. Noblesse

Data presented in Table 4.1.17 and Appendix 17 indicate that flower diameter after cold storage, on 3rd day in vase, and on complete flower opening varied significantly over control (water-treated). Non-significant variations were recorded in flower diameter at harvest. After cold storage, highest flower diameter was noted with gamma irradiation dose of 0.025 kGy. With ^{60}Co dose of 0.025 kGy after cold storage, highest flower diameter (2.85 cm) was noted in 11 day's treatment whereas the lowest (2.07 cm) in three day's treatment. With irradiation dose of 0.05 kGy after cold storage, highest flower diameter (2.52 cm) was recorded in 11 day's treatment whereas the lowest (2.04 cm) in three day's treatment. Highest flower diameter (2.47

Table 4.1.18 Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on flower quality of cut rose cv. Noblesse (vase lives are given in Table 16)

Storage days	Flower diameter (cm)											
	At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
3	1.61	1.59	1.62	1.99	1.95	1.91	4.83	4.70	4.67	7.66	7.59	7.35
4	1.57	1.57	1.59	2.01	1.97	1.94	4.75	4.65	4.63	7.41	7.35	7.29
5	1.56	1.58	1.57	2.05	2.00	1.98	4.69	4.44	4.41	7.25	7.07	7.01
6	1.59	1.61	1.60	2.06	2.03	2.00	4.50	4.35	4.32	7.18	6.81	6.72
7	1.62	1.55	1.53	2.07	2.05	2.04	4.27	4.15	4.09	6.75	6.57	6.48
8	1.58	1.56	1.56	2.12	2.10	2.08	4.09	3.92	3.86	6.42	6.20	6.09
9	1.60	1.57	1.59	2.23	2.18	2.12	3.94	3.81	3.76	6.05	5.93	5.71
10	1.57	1.60	1.61	2.30	2.25	2.19	3.82	3.74	3.60	5.81	5.72	5.43
11	1.55	1.56	1.58	2.45	2.39	2.33	3.71	3.65	3.49	5.69	5.48	5.10
12	1.54	1.62	1.57	2.40	2.36	2.25	3.65	3.54	3.44	5.47	5.29	4.94
Control	1.58	1.58	1.58	-	-	-	4.25	4.25	4.25	6.85	6.85	6.85
SEm±	0.030	0.030	0.030	0.031	0.031	0.030	0.070	0.088	0.079	0.106	0.101	0.105
F test	NS	NS	NS	**	**	**	**	*	**	**	**	*
CD at 5%	-	-	-	0.091	0.090	0.088	0.205	0.257	0.230	0.311	0.276	0.305

NS = Non significant
** = Highly significant
* = Significant

cm) after cold storage was recorded with irradiation dose 0.10 kGy in 11 day's treatment whereas the lowest (2.01 cm) in three day's treatment. Flower diameter on 3rd day in vase with ^{60}Co dose of 0.025 kGy was found better than 0.05 and 0.10 kGy. With irradiation dose 0.025 kGy on 3rd day in vase, highest flower diameter (5.02 cm) was recorded in three day's treatment whereas the minimum (4.00 cm) in 12 day's treatment. With ^{60}Co dose of 0.05 kGy on 3rd day in vase, highest flower diameter (5.00 cm) was noted in three day's treatment whereas the minimum (3.92 cm) in 12 day's treatment. Highest flower diameter (4.88 cm) on 3rd day in vase was recorded with irradiation dose of 0.10 kGy in three day's treatment whereas the minimum (3.79 cm) in 12 day's treatment. Flower diameter value on 3rd day in vase for control was 4.25 cm. Significant variations in flower diameter on 3rd day in vase were recorded up to seven day's treatments with gamma irradiation dose of 0.025 kGy and up to six days with 0.05 and 0.10 kGy. Gamma irradiation dose of 0.025 kGy was found better in respect to flower diameter at complete expansion. With irradiation dose of 0.025 kGy on complete flower expansion, maximum flower diameter (7.80 cm) was recorded in three day's treatment whereas the minimum (5.90 cm) in 12 day's treatment. With ^{60}Co dose of 0.05 kGy, on complete flower opening highest flower diameter (7.74 cm) was recorded in three day's treatment whereas the minimum (5.75 cm) in 12 day's treatment. On complete flower expansion, maximum flower diameter (7.70 cm) was recorded with irradiation dose of 0.10 kGy in three day's treatment whereas the minimum (5.61 cm) in 12 day's treatment. Significant variations in flower diameter on complete flower expansion were recorded up to seven day's treatments with gamma rays 0.025 kGy and up to six day's treatments with 0.05 and 0.10 kGy.

4.1.18 Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on flower quality of cut rose cv. Noblesse

It is clearly evident from Table 4.1.18 and Appendix 18 that flower diameter after cold storage, on 3rd day in vase, and on complete flower opening varied significantly over control. Non significant variations were recorded in flower diameter at harvest. Maximum flower diameter after cold storage was recorded in three day's treatment with all the three irradiation doses whereas the minimum in 12 day's treatment. Among the three doses, maximum flower expansion after cold storage was

Table 4.1.19 Effect of gamma irradiations (0.025 and 0.05 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on water uptake of cut rose cv. Noblesse (vase lives are given in Table 15)

Storage days	Water uptake (ml) in days after keeping cut flowers in vase (water)																							
	1		2		3		4		5		6		7		8		9		10		11		12	
	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05
3	2.75	2.71	7.20	7.14	12.13	11.26	15.72	15.67	19.23	19.17	22.46	22.35	25.47	25.30	27.91	27.80	29.96	29.82	31.70	31.56	32.66	32.50	32.84	32.72
4	2.63	2.58	7.08	7.01	11.80	10.95	15.43	15.36	18.77	18.70	21.98	21.81	24.82	24.60	26.85	26.63	28.21	28.05	29.03	29.72	30.25	30.04		
5	2.54	2.47	6.93	6.85	10.92	10.70	15.07	14.99	17.35	17.26	20.59	20.42	23.71	23.63	24.27	24.08	26.45	26.31	27.43	27.24	28.27	27.89		
6	2.46	2.39	6.67	6.68	10.31	10.22	14.30	14.22	16.81	16.70	19.82	19.63	22.35	22.30	23.90	23.87	25.08	24.39	25.67	24.35				
7	2.37	2.33	6.51	6.42	9.79	9.73	14.15	14.03	16.02	15.93	19.48	19.26	21.73	21.54	21.84	21.70	22.81	22.02	23.20					
8	2.26	2.18	6.24	6.13	9.62	9.57	13.41	13.35	15.81	15.65	18.92	18.80	21.10	20.95	20.76	21.10	21.35							
9	2.15	2.06	6.02	5.82	9.23	9.15	13.09	12.98	15.16	15.01	18.37	18.21	20.35	20.17	20.45	20.32								
10	1.97	1.83	5.77	5.31	8.85	8.76	12.60	12.51	14.63	14.12	17.21	17.05	18.46	17.26	19.20									
11	1.82	1.70	5.48	4.92	8.64	8.60	11.43	11.30	13.92	12.60	16.82	12.85	17.31											
12	1.69	1.62	5.13	4.68	8.38	7.92	10.97	9.85	12.17	10.15														
Control	2.26	2.26	6.27	6.27	9.66	9.66	12.92	12.92	15.97	15.97	18.59	18.59	21.18	21.18	22.85	22.85	23.11	23.11						
SEm±	0.044	0.036	0.119	0.115	0.163	0.156	0.213	0.252	0.323	0.195	0.359	0.290	0.353	0.372	0.390	0.334	0.449	0.405	0.306	0.275	0.253	0.267		
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**		
CD at 5%	0.120	0.104	0.346	0.337	0.477	0.456	0.623	0.734	0.943	0.569	1.047	0.846	1.031	1.086	1.139	0.974	1.311	1.182	0.894	0.802	0.739	0.779		

** = Highly significant

recorded with 0.20 kGy whereas the minimum with 0.60 kGy. With ^{60}Co dose of 0.20 kGy maximum flower diameter after cold storage was observed in 12 day's treatment. On 3rd day in vase, irradiation dose of 0.20 kGy was found better than 0.40 and 0.60 kGy. With gamma rays 0.20 kGy on 3rd day in vase, maximum flower diameter (4.83 cm) was recorded in three day's treatment whereas minimum (3.44 cm) with gamma rays dose of 0.60 kGy in 12 day's treatment. Flower diameter value on 3rd day in vase for control was 4.25 cm. Significant variations in flower diameter on 3rd day in vase with irradiation dose of 0.20 kGy were recorded up to six day's treatments. On the other hand, significant variations in flower diameter on 3rd day in vase with irradiation doses of 0.40 and 0.60 kGy were observed up to four day's treatment. On complete flower expansion, gamma rays dose 0.20 kGy was found better than 0.40 and 0.60 kGy. With irradiation dose of 0.20 kGy on complete flower expansion maximum flower diameter (7.66 cm) was recorded in three day's treatment whereas the minimum (4.94 cm) with 0.60 kGy in 12 day's treatment. Flower diameter at complete expansion for control was 6.85 cm. Significant variations in flower diameter on complete flower expansion with irradiation dose of 0.20 kGy were recorded up to six day's treatments. With irradiation doses of 0.40 and 0.60 kGy, significant variations in flower diameter at complete flower expansion were noted up to four day's treatments. Hence, it is concluded that gamma rays 0.20 kGy is better than 0.40 and 0.60 kGy for expansion of flower diameter at various stages of postharvest life of 'Noblesse' cut rose.

4.1.19 Effect of gamma irradiations (0.025 and 0.05 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on water uptake of cut rose cv. Noblesse

Perusal of Table 4.1.19 and Appendix 19 indicates that water uptake after 24 h intervals varied significantly with irradiation doses of 0.025 and 0.05 kGy over control. Highest total water uptake (32.84 ml) was recorded with gamma dose 0.025 kGy in three day's treatment. Lowest total water uptake (10.15 ml) was observed with gamma rays of 0.05 kGy in 12 day's treatment. Total water uptake value for control was 23.11 ml. With both irradiation doses, significant variations in water uptake after 24 h intervals were recorded up to six day's treatments. Higher water uptake on different days was recorded with ^{60}Co dose of 0.025 kGy than 0.05 kGy. Irrespective of gamma rays doses, highest water uptake was recorded in three day's treatment

Table 4.1.20 Effect of gamma irradiations (0.10 and 0.20 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on water uptake of cut rose cv. Noblesse (vase lives are given in Table 15 and 16)

Storage days	Water uptake (ml) in days after keeping cut flowers in vase (water)																				
	1		2		3		4		5		6		7		8		9		10		11
	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10
3	2.65	2.61	7.06	6.97	11.15	10.80	14.50	14.29	17.89	17.60	21.00	20.61	23.80	23.31	26.20	25.71	28.08	27.45	29.70	28.01	31.81
4	2.50	2.45	6.91	6.80	10.62	10.46	14.12	13.91	17.40	17.10	20.45	19.97	23.00	22.59	25.15	24.70	27.13	25.40	28.50		29.45
5	2.41	2.38	6.77	6.64	10.30	10.28	13.66	13.76	16.98	16.86	19.86	19.40	22.51	22.11	24.21	23.96	25.08	24.71	25.20		
6	2.38	2.25	6.68	6.39	10.21	9.51	13.55	12.80	16.69	15.80	19.67	18.25	22.10	20.40	23.71	22.16	24.21	22.96			
7	2.24	2.18	6.36	6.10	9.64	9.15	13.35	11.95	15.80	14.69	19.11	17.13	21.35	18.05	21.56	18.21	21.80				
8	2.10	1.97	6.00	5.73	9.45	8.60	12.70	11.22	15.42	13.80	16.70	14.50	17.55		17.70						
9	1.93	1.75	5.72	5.31	8.82	7.84	12.17	10.57	14.65	12.91	16.13	13.07	16.33								
10	1.75	1.55	5.20	4.42	7.61	7.10	11.15	9.46	13.70	11.62	13.95										
11	1.56	1.39	4.70	4.35	7.05	6.41	9.37	8.71	9.94	9.05											
12	1.49	1.26	3.85	3.80	6.44	5.96	7.40	6.30	7.55												
Control	2.26	2.26	6.27	6.27	9.66	9.66	12.92	12.92	15.97	15.97	18.59	18.59	21.18	21.18	22.85	22.85	23.11	23.11			
SEm±	0.034	0.030	0.110	0.088	0.173	0.189	0.197	0.272	0.238	0.228	0.266	0.238	0.283	0.299	0.289	0.326	0.339	0.336	0.272		
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**		
CD at 5%	0.100	0.111	0.343	0.258	0.505	0.552	0.574	0.794	0.675	0.667	0.776	0.695	0.826	0.871	0.845	0.953	0.998	0.982	0.793		

** = Highly significant

Table 4.1.21 Effect of gamma irradiations (0.40 and 0.60 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on water uptake of cut rose cv. Noblesse (vase lives are given in Table 16)

Storage days	Water uptake (ml) in days after keeping cut flowers in vase (water)																	
	1		2		3		4		5		6		7		8		9	
	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60
3	2.55	2.47	6.80	6.70	10.41	10.19	14.07	13.65	17.07	16.85	20.04	19.48	22.73	22.15	23.78	22.20	23.92	22.31
4	2.32	2.30	6.61	6.39	10.04	8.90	13.40	12.18	16.52	15.22	19.20	18.69	21.84	19.96	22.35	20.21	22.50	
5	2.29	2.16	6.40	6.17	9.55	8.33	12.35	11.47	15.82	14.20	18.27	17.52	18.70	18.57	18.96	18.92		
6	2.22	2.08	6.19	5.90	8.89	7.93	11.84	10.91	14.35	11.25	17.55	11.75	17.91	12.08	18.05			
7	1.89	1.72	5.70	5.41	6.51	6.97	8.70	10.68	9.15	11.05	9.61	11.50		11.67				
8	1.80	1.55	5.51	5.04	8.07	7.40	9.35	8.21	9.52	8.53								
9	1.58	1.44	4.98	4.60	7.36	6.81	8.40	7.27	8.61	7.56								
10	1.47	1.36	4.60	4.28	5.71	6.17	5.97	6.34										
11	1.24	1.10	3.95	3.66	4.27	5.38	4.46	5.60										
12	1.07	0.91	3.48	3.20	5.40	3.45	5.55											
Control	2.26	2.26	6.27	6.27	9.66	9.66	12.92	12.92	15.97	15.97	18.59	18.59	21.18	21.18	22.85	22.85	23.11	23.11
SEm±	0.037	0.029	0.120	0.085	0.147	0.143	0.192	0.184	0.228	0.253	0.234	0.262	0.230	0.381	0.268	0.234	0.235	
F test	**	**	**	**	**	*	**	**	**	*	**	*	**	*	*	NS	*	
CD at 5%	0.109	0.085	0.351	0.247	0.429	0.416	0.559	0.537	0.666	0.737	0.683	0.766	0.695	0.880	0.782	-	0.687	

NS = Non significant
** = Highly significant
* = Significant

whereas the lowest in 12 day's treatment. Hence, it is concluded that gamma rays dose of 0.025 kGy is better in respect of water uptake which manifested in the form of increased vase life and quality of cut flowers.

4.1. 20 Effect of gamma irradiations (0.10 and 0.20 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on water uptake of cut rose cv. Noblesse

Water uptake after 24 h intervals varied significantly with ^{60}Co doses of 0.10 and 0.20 kGy over control (Table 4.1.20 and Appendix 20). Highest total water uptake (30.81 ml) was recorded with gamma rays dose of 0.10 kGy in three day's treatment whereas the lowest (6.30 ml) with irradiation dose of 0.20 kGy in 12 day's treatment. Total water uptake for control was 23.11 ml. Higher water uptake at different days was recorded with irradiation dose of 0.10 kGy than 0.20 kGy. With both irradiation doses, highest water uptake was recorded in three day's treatment whereas the lowest in 12 day's treatment. Significant variations in water uptake with ^{60}Co dose of 0.10 kGy were recorded up to six day's treatments whereas with 0.20 kGy up to five day's treatments. Hence, it is concluded that higher water uptake with gamma rays of 0.10 kGy resulted in increased vase life and quality of 'Noblesse' cut flowers.

4.1. 21 Effect of gamma irradiations (0.40 and 0.60 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on water uptake of cut rose cv. Noblesse

Data presented in Table 4.1.21 and Appendix 21 reveal that water uptake at 24 h intervals varied significantly with gamma rays of 0.40 and 0.60 kGy over control. Highest total water uptake (23.92 ml) was recorded with gamma rays of 0.40 kGy in three day's treatment, whereas the lowest (3.45 ml) with 0.60 kGy in 12 day's treatment. Total water uptake value for control was 23.11 ml. Higher water uptake was recorded with ^{60}Co dose of 0.40 kGy than 0.60 kGy. As the flowers progressed towards senescence reduction in water uptake was noted. Significant variations in water uptake at 24 h intervals with both doses were recorded up to three day's treatment. Higher water uptake with ^{60}Co dose of 0.40 kGy resulted in increased vase life than that of 0.60 kGy.

Table 4.2.1 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Golden Gate

Storage days	Changes in fresh weight (g)									Changes in dry weight (g)									Vase life (days)		
	After cold storage			On 3rd day in vase			On senescence day in vase			After cold storage			On 3rd day in vase			On senescence day in vase			0.025	0.05	0.10
	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10			
2	0.76	0.69	0.65	0.97	0.90	0.86	-0.25	-0.28	-0.31	0.16	0.15	0.14	0.21	0.19	0.18	-0.05	-0.06	-0.06	13.00	12.33	12.00
3	0.95	0.90	0.84	1.15	1.09	1.02	-0.60	-0.64	-0.69	0.20	0.19	0.18	0.24	0.23	0.22	-0.13	-0.14	-0.15	12.33	12.00	11.33
4	1.20	1.14	1.10	1.32	1.25	1.19	-0.66	-0.71	-0.75	0.25	0.24	0.23	0.28	0.26	0.25	-0.14	-0.15	-0.16	11.33	11.00	10.00
5	1.45	1.38	1.31	1.59	1.51	1.45	-0.87	-0.92	-0.96	0.31	0.29	0.28	0.34	0.32	0.31	-0.18	-0.19	-0.20	10.66	10.33	9.33
6	1.77	1.71	1.65	1.97	1.92	1.88	-0.98	-1.04	-1.10	0.38	0.36	0.35	0.42	0.41	0.39	-0.21	-0.22	-0.23	9.33	9.00	8.66
7	1.64	1.58	1.50	1.80	1.74	1.68	-1.09	-1.14	-1.19	0.35	0.33	0.32	0.38	0.37	0.36	-0.23	-0.24	-0.25	8.00	8.00	7.66
8	1.43	1.36	1.31	1.66	1.59	1.50	-1.18	-1.25	-1.32	0.30	0.29	0.28	0.35	0.34	0.32	-0.25	-0.26	-0.28	7.33	7.00	6.33
9	1.32	1.25	1.18	1.52	1.45	1.38	-1.40	-1.47	-1.53	0.28	0.26	0.25	0.32	0.31	0.29	-0.30	-0.31	-0.32	6.33	6.00	5.33
10	1.18	1.11	1.06	1.33	1.26	1.20	-1.57	-1.64	-1.68	0.25	0.24	0.22	0.28	0.27	0.25	-0.33	-0.35	-0.36	5.66	5.33	5.00
Control	-	-	-	0.64	0.64	0.64	-2.20	-2.20	-2.20	-	-	-	0.14	0.14	0.14	-0.47	-0.47	-0.47	8.00	8.00	8.00
SEm±	0.020	0.020	0.019	0.010	0.022	0.021	0.021	0.018	0.022	0.003	0.004	0.004	0.004	0.005	0.003	0.004	0.004	0.004	0.145	0.114	0.095
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
CD at 5%	0.058	0.057	0.054	0.053	0.066	0.063	0.061	0.053	0.065	0.008	0.012	0.011	0.013	0.013	0.010	0.013	0.012	0.012	0.422	0.333	0.277

\- Indicates loss in fresh/dry weight over the fresh/dry weight at harvest

** = Highly significant

4.2 POSTHARVEST LIFE OF CUT ROSES AS INFLUENCED BY GAMMA IRRADIATION, PULSING, AND WET COLD STORAGE

4.2.1 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Golden Gate

Changes in fresh and dry weights after cold storage, on 3rd day in vase, and on senescence day in vase, and vase lives varied significantly with gamma rays doses of 0.025, 0.05, and 0.10 kGy over control (Table 4.2.1 and Appendix 22). After cold storage, maximum gain in fresh weight was recorded with gamma rays dose of 0.025 kGy. Gain in fresh weights after cold storage was recorded in increasing order up to six day's treatments with all the three doses. After cold storage, maximum gain in fresh weight (1.77 g) was recorded with irradiation dose of 0.025 kGy in six day's treatment whereas the minimum (0.65 g) with 0.10 kGy in two day's treatment. On 3rd day in vase, gain in fresh weights was higher in flowers treated with 0.025 kGy than 0.05 and 0.10 kGy. With all the three doses, gain in fresh weights in increasing order was recorded up to six day's treatments. On 3rd day in vase, gain in fresh weight (1.97 g) was recorded with gamma irradiation dose of 0.025 kGy in six day's treatment whereas the minimum (0.86 g) with irradiation dose 0.10 kGy in two day's treatment. On 3rd day in vase, gain in fresh weight for control was 0.64 g. Loss in fresh weights in increasing order on senescence day in vase was observed with increase in storage duration. Minimum loss in fresh weight (-0.25 g) was recorded with gamma rays dose of 0.025 kGy in two day's treatment whereas the minimum (-1.68 g) with 0.10 kGy in 10 day's treatment. Loss in fresh weight on senescence day in vase for control was -2.02 g. Corresponding changes in dry weights at various stages of vase life evaluation were also recorded. Maximum vase life (13.00 days) was recorded with gamma rays dose of 0.025 kGy in two day's treatment whereas the minimum (5.00 days) with 0.10 kGy in 10 day's treatment. With respect to vase life, gamma irradiation dose of 0.025 kGy was found better than 0.05 and 0.10 kGy. Reduction in vase life was recorded, as the storage duration increased. Vase life value for control was 8.00 days. Significant variations in vase life up to six days were recorded with all the three gamma irradiation doses. Hence, it is concluded that cut flowers of 'Golden Gate' rose after treatment with any one of gamma rays doses (0.025, 0.05, and 0.10 kGy) and pulsing, could be wet cold stored (2^0C) for six days without affecting the ultimate life in vase.

Table 4.2.2 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2°C) on changes in fresh and dry weights, and vase lives of cut rose cv. Golden Gate

Storage days	Changes in fresh weight (g)									Changes in dry weight (g)									Vase life (days)		
	After cold storage			On 3rd day in vase			On senescence day in vase			After cold storage			On 3rd day in vase			On senescence day in vase			0.20	0.40	0.60
	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60			
2	0.59	0.54	0.50	0.80	0.74	0.69	-0.33	-0.36	-0.39	0.12	0.11	0.11	0.17	0.16	0.15	-0.07	-0.08	-0.08	11.00	10.00	9.00
3	0.78	0.75	0.66	0.96	0.90	0.86	-0.74	-0.77	-0.81	0.16	0.16	0.14	0.20	0.19	0.18	-0.16	-0.16	-0.17	10.66	9.66	8.66
4	1.04	0.99	0.61	1.15	1.08	0.78	-0.81	-0.86	-0.91	0.22	0.21	0.13	0.24	0.23	0.16	-0.17	-0.18	-0.19	9.33	9.00	7.66
5	1.27	0.92	0.53	1.36	0.99	0.70	-1.02	-1.07	-1.13	0.27	0.19	0.11	0.29	0.21	0.15	-0.22	-0.23	-0.24	8.66	8.00	7.00
6	1.13	0.85	0.44	1.24	0.90	0.64	-1.13	-1.18	-1.25	0.24	0.18	0.09	0.26	0.19	0.13	-0.24	-0.25	-0.26	8.00	7.33	6.33
7	1.04	0.72	0.38	1.15	0.83	0.57	-1.25	-1.32	-1.45	0.22	0.15	0.08	0.24	0.18	0.12	-0.26	-0.28	-0.31	7.00	6.33	5.66
8	0.93	0.65	0.31	1.04	0.75	0.45	-1.38	-1.45	-1.57	0.20	0.14	0.06	0.22	0.16	0.09	-0.29	-0.31	-0.33	6.33	5.66	5.00
9	0.86	0.60	0.24	0.95	0.68	0.38	-1.59	-1.68	-1.79	0.18	0.13	0.05	0.20	0.14	0.08	-0.34	-0.36	-0.38	5.00	5.00	4.66
10	0.78	0.53	0.17	0.88	0.61	0.31	-1.75	-1.89	-1.98	0.16	0.11	0.03	0.19	0.13	0.06	-0.37	-0.40	-0.42	5.00	4.66	4.33
Control	-	-	-	0.64	0.64	0.64	-2.20	-2.20	-2.20	-	-	-	0.14	0.14	0.14	-0.47	-0.47	-0.47	8.00	8.00	8.00
SEm±	0.014	0.009	0.007	0.017	0.010	0.008	0.016	0.018	0.018	0.002	0.002	0.001	0.003	0.002	0.002	0.005	0.004	0.003	0.112	0.113	0.087
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
CD at 5%	0.062	0.026	0.019	0.049	0.030	0.023	0.048	0.051	0.052	0.007	0.007	0.004	0.008	0.005	0.005	0.014	0.011	0.010	0.328	0.330	0.254

- Indicates loss in fresh/dry weight over the fresh/dry weight at harvest
** = Highly significant

Table 4.2.3 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on flower quality of cut rose cv. Golden Gate (vase lives are given in Table 22)

Storage days	Flower diameter (cm)											
	At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
2	1.65	1.65	1.64	3.15	3.09	3.04	5.15	5.11	5.07	8.02	7.96	7.90
3	1.67	1.66	1.63	3.24	3.18	3.11	5.11	5.06	5.00	7.90	7.90	7.84
4	1.68	1.68	1.68	3.39	3.35	3.29	5.08	5.02	4.94	7.81	7.82	7.73
5	1.66	1.69	1.67	3.54	3.46	3.37	5.04	4.97	4.89	7.72	7.71	7.64
6	1.64	1.64	1.66	3.66	3.60	3.51	4.97	4.85	4.85	7.60	7.52	7.56
7	1.66	1.65	1.66	3.77	3.71	3.62	4.66	4.60	4.56	7.36	7.27	7.35
8	1.67	1.66	1.67	3.86	3.79	3.73	4.60	4.52	4.35	7.22	7.13	7.02
9	1.65	1.65	1.64	3.92	3.84	3.79	4.44	4.38	4.21	6.85	6.78	6.79
10	1.67	1.67	1.65	3.98	3.90	3.84	4.30	4.20	4.10	6.60	6.51	6.41
Control	1.66	1.66	1.66	-	-	-	4.47	4.47	4.47	7.03	7.03	7.03
SEm±	0.021	0.021	0.017	0.037	0.052	0.062	0.073	0.057	0.056	0.213	0.092	0.113
F test	NS	NS	NS	**	**	**	**	**	**	**	**	**
CD at 5%	-	-	-	0.109	0.152	0.101	0.213	0.167	0.168	0.358	0.267	0.330

NS = Non significant
** = Highly significant

4.2.2 Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Golden Gate

Perusal of Table 4.2.2 and Appendix 23 reveals that changes in fresh and dry weights after cold storage, on 3rd day in vase, and on senescence day in vase, and vase life varied significantly with gamma doses of 0.20, 0.40, and 0.60 kGy over control. After cold storage, maximum gain in fresh weight (1.27 g) was recorded with gamma irradiation dose of 0.20 kGy in five day's treatment. After cold storage, gain in fresh weights in increasing order was observed up to five, four, and three day's treatments with irradiation doses of 0.20, 0.40, and 0.60 kGy, respectively. On 3rd day in vase, maximum gain in fresh weight (1.36 g) was recorded with gamma rays 0.20 kGy in five day's treatment whereas the minimum (0.31 g) with 0.60 kGy in 10 day's treatment. On 3rd day in vase, gain in fresh weight for control was 0.64 g. Gain in fresh weights in increasing order on 3rd day in vase was observed up to five, four, and three day's treatments with irradiation doses of 0.20, 0.40, and 0.60 kGy, respectively. On senescence day in vase, minimum loss in fresh weight (-0.33 g) was recorded with gamma rays dose of 0.20 kGy in two day's treatment whereas the maximum (-1.98 g) with 0.60 kGy in 10 day's treatment. On senescence day in vase, loss in fresh weights in increasing order was recorded with increase in storage duration. Loss in fresh weight on senescence day in vase for control was -2.20 g. Corresponding changes in dry weights were recorded at various stages of post-storage life of cut flowers. Maximum vase life (11.00 days) was recorded with irradiation dose of 0.20 kGy in two days treatment whereas the minimum (4.33 days) with 0.60 kGy in 10 day's treatment. Decrease in vase life was noted with all the three doses as storage duration increased. Vase life value for control was 8.00 days. Significant variations in vase life were recorded up to five, four, and three day's treatments with ^{60}Co doses of 0.20, 0.40, and 0.60 kGy, respectively.

4.2.3 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent), and dry cold storage (2^0C) on flower quality of cut rose cv. Golden Gate

It is clear from Table 4.2.3 and Appendix 24 that flower diameter after cold storage, on 3rd day in vase, and on complete expansion varied significantly with gamma irradiation doses of 0.025, 0.05, and 0.10 kGy over control. Variations in

Table 4.2.4 Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on flower quality of cut rose cv. Golden Gate (vase lives are given in Table 23)

Storage days	Flower diameter (cm)											
	At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
2	1.65	1.66	1.63	2.98	2.94	2.87	5.02	4.96	4.85	7.84	7.78	7.70
3	1.66	1.68	1.65	3.05	3.00	2.94	4.95	4.87	4.69	7.80	7.69	7.42
4	1.64	1.69	1.66	3.21	3.14	3.05	4.84	4.75	4.52	7.70	7.50	7.29
5	1.67	1.65	1.68	3.29	3.22	3.10	4.73	4.60	4.25	7.52	7.31	7.20
6	1.68	1.67	1.67	3.40	3.30	3.17	4.59	4.42	4.13	7.26	7.22	7.03
7	1.66	1.63	1.66	3.52	3.41	3.28	4.41	4.33	4.04	7.15	6.96	6.74
8	1.67	1.65	1.68	3.60	3.48	3.34	4.29	4.26	3.95	6.88	6.75	6.52
9	1.63	1.64	1.65	3.68	3.56	3.45	4.15	4.15	3.86	6.59	6.53	6.29
10	1.68	1.65	1.66	3.79	3.60	3.51	4.03	3.92	3.78	6.32	6.20	6.11
Control	1.66	1.66	1.66	-	-	-	4.47	4.47	4.47	7.03	7.03	7.03
SEm±	0.021	0.027	0.018	0.034	0.039	0.046	0.068	0.068	0.070	0.097	0.117	0.104
F test	NS	NS	NS	**	**	**	**	**	**	**	**	**
CD at 5%	-	-	-	0.099	0.113	0.134	0.199	0.199	0.205	0.282	0.343	0.303

NS = Non significant
** = Highly significant

flower diameter at harvest were non significant. After cold storage, maximum flower diameter was recorded with irradiation dose of 0.025 kGy than 0.05 and 0.10 kGy. After cold storage, maximum flower diameter (3.98 cm) was recorded with ^{60}Co dose of 0.025 kGy in 10 day's treatment whereas the minimum (3.04 cm) with 0.10 kGy in two day's treatment. Increase in flower diameter during wet cold storage was noted with increase in storage duration. On 3rd day in vase, maximum flower diameter (5.15 cm) was recorded with gamma irradiation dose of 0.025 kGy in two day's treatment whereas the minimum (4.10 cm) with irradiation dose of 0.10 kGy in 10 day's treatment. Maximum flower expansion on 3rd day in vase for control was 4.47 cm. On 3rd day in vase, significant variations in flower diameter were recorded up to six day's treatments with gamma irradiation doses of 0.025, 0.05, and 0.10 kGy. On complete flower expansion, maximum flower diameter of 8.02 cm was recorded with gamma rays dose of 0.025 kGy in two day's treatment whereas the minimum (6.41 cm) with 0.10 kGy in 10 day's treatment. On complete flower opening, decrease in flower diameter was recorded as the storage duration increased. Flower diameter on complete expansion for control was 7.03 cm. Significant variations in flower diameter on complete expansion were recorded up to six day's treatments with irradiation doses of 0.025, 0.05, and 0.10 kGy. Hence, it is concluded that cut flowers after subjecting to any one of these irradiation doses and pulsing with sucrose, could be wet cold stored (2^0C) for six days without decline in flower quality over untreated cut flowers.

4.2.4 Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on flower quality of cut rose cv. Golden Gate

Perusal of Table 4.2.4 and Appendix 25 indicates that flower diameter after cold storage, on 3rd day in vase, and on complete opening varied significantly with gamma irradiation doses of 0.20, 0.40, and 0.60 kGy over control. Variations in flower diameter at harvest were non- significant. Gamma irradiation dose of 0.20 kGy was found better than 0.40 and 0.60 kGy in respect of increase in flower diameter during storage. After cold storage, maximum flower diameter (3.79 cm) was recorded with gamma rays dose of 0.20 kGy in 10 days treatment whereas the minimum 2.87 cm with 0.60 kGy in two day's treatment. Increase in flower diameter was noted during storage with the increase in storage duration. On 3rd day in vase, gamma irradiation dose of 0.20 kGy was found better in terms of increasing flower diameter

Table 4.2.5 Effect of gamma irradiations (0.025 and 0.05 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on water uptake of cv. Golden Gate (vase lives are given in Table 22)

Storage days	Water uptake (ml) in days after keeping cut flowers in vase (water)																									
	1		2		3		4		5		6		7		8		9		10		11		12		13	
	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05
2	3.05	2.98	7.50	7.41	12.63	12.55	15.99	15.80	19.57	19.42	22.84	22.65	25.78	25.61	28.40	28.29	30.52	30.39	32.07	31.86	33.10	32.98	34.70	33.38	34.95	33.62
3	2.94	2.87	7.33	7.25	12.26	12.20	15.52	15.38	19.21	19.06	22.38	22.22	25.20	25.07	28.06	27.91	30.15	30.01	31.40	31.25	32.80	31.65	33.25	31.97	33.92	
4	2.80	2.73	7.15	7.05	11.92	11.73	15.13	14.97	18.40	18.23	21.70	21.59	24.62	24.48	27.41	27.22	29.27	29.06	31.18	30.42	31.74	30.73	31.90			
5	2.72	2.61	6.98	6.92	11.65	11.32	14.60	14.35	17.72	17.54	20.13	19.89	23.17	22.80	26.13	25.88	28.28	27.05	29.72	28.14	30.13	28.35				
6	2.60	2.55	6.85	6.79	10.27	10.20	13.92	13.99	17.45	16.91	19.72	19.65	22.43	22.37	24.86	24.78	25.24	25.66	25.87							
7	2.41	2.36	6.40	6.36	9.62	9.61	13.25	13.17	16.30	16.27	19.06	18.80	20.52	20.45	21.08	20.92		21.28								
8	2.24	2.19	6.22	6.13	9.00	8.92	12.63	12.42	15.16	14.90	16.82	16.72	17.31	17.16	17.76											
9	2.03	1.95	5.93	5.80	8.27	8.10	11.74	11.55	12.68	12.52	13.16	12.87	13.45													
10	1.87	1.70	4.35	4.03	6.72	6.55	7.95	7.76	8.46	8.28	8.67	8.46														
Control	2.36	2.36	6.38	6.38	9.78	9.78	13.08	13.08	16.20	16.20	18.70	18.70	21.33	21.33	23.02	23.02										
SEm±	0.027	0.030	0.063	0.080	0.133	0.096	0.160	0.208	0.381	0.201	0.232	0.238	0.328	0.311	0.236	0.264	0.305	0.324	0.256	0.243	0.142	0.242	0.206			
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**			
CD at 5%	0.080	0.089	0.185	0.234	0.387	0.281	0.489	0.607	1.113	0.506	0.678	0.695	0.957	0.907	0.690	0.771	0.890	0.946	0.748	0.723	0.413	0.706	0.601			

** = Highly significant

Table 4.2.6 **Effect of gamma irradiations (0.10 and 0.20 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on water uptake of cut rose cv. Golden Gate (vase lives are given in Tables 22 and 23)**

Storage days	Water uptake (ml) in days after keeping cut flowers in vase (water)																							
	1		2		3		4		5		6		7		8		9		10		11		12	
	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20
2	2.94	2.89	7.34	7.25	12.48	12.30	15.71	15.62	19.35	19.22	22.54	22.40	25.49	25.38	28.18	28.09	30.31	30.15	31.60	30.76	31.96	31.08	32.25	
3	2.82	2.74	7.19	7.10	12.13	12.04	15.29	15.18	18.94	18.82	22.10	21.98	24.96	24.81	27.78	27.57	29.62	28.17	29.97	28.58	30.60	28.91	30.98	
4	2.66	2.62	6.97	6.84	11.60	11.47	14.86	14.73	18.13	17.97	21.45	21.32	24.30	24.15	25.12	25.06	25.67	25.62	26.17					
5	2.52	2.54	6.84	6.75	11.22	11.00	14.19	13.92	17.25	17.09	19.89	19.65	23.57	22.33	25.60	24.90	26.23	25.35	26.54					
6	2.49	2.41	6.70	6.59	10.43	10.05	13.71	13.54	16.99	16.65	19.73	19.40	22.52	21.78	24.62	22.15	24.90							
7	2.30	2.28	6.29	6.23	9.50	9.42	13.05	12.90	16.12	15.94	18.61	18.35	20.23	19.12	20.64									
8	2.15	2.10	5.97	5.86	8.80	8.69	12.26	12.13	14.74	14.56	16.53	15.20	17.05	15.67										
9	1.88	1.73	5.71	5.56	7.98	7.81	11.40	9.05	12.37	9.47	12.66													
10	1.65	1.49	3.92	3.77	6.41	6.32	7.57	7.40	7.89	7.82														
Control	2.36	2.36	6.38	6.38	9.78	9.78	13.08	13.08	16.20	16.20	18.70	21.33	21.33	21.33	23.02	23.02								
SEm±	0.024	0.037	0.093	0.098	0.177	0.124	0.164	0.194	0.255	0.195	0.308	0.266	0.306	0.244	0.288	0.325	0.297	0.214	0.201					
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**					
CD at 5%	0.071	0.108	0.271	0.285	0.517	0.363	0.408	0.565	0.744	0.570	0.900	0.777	0.893	0.711	0.840	0.950	0.866	0.625	0.586					

** = Highly significant

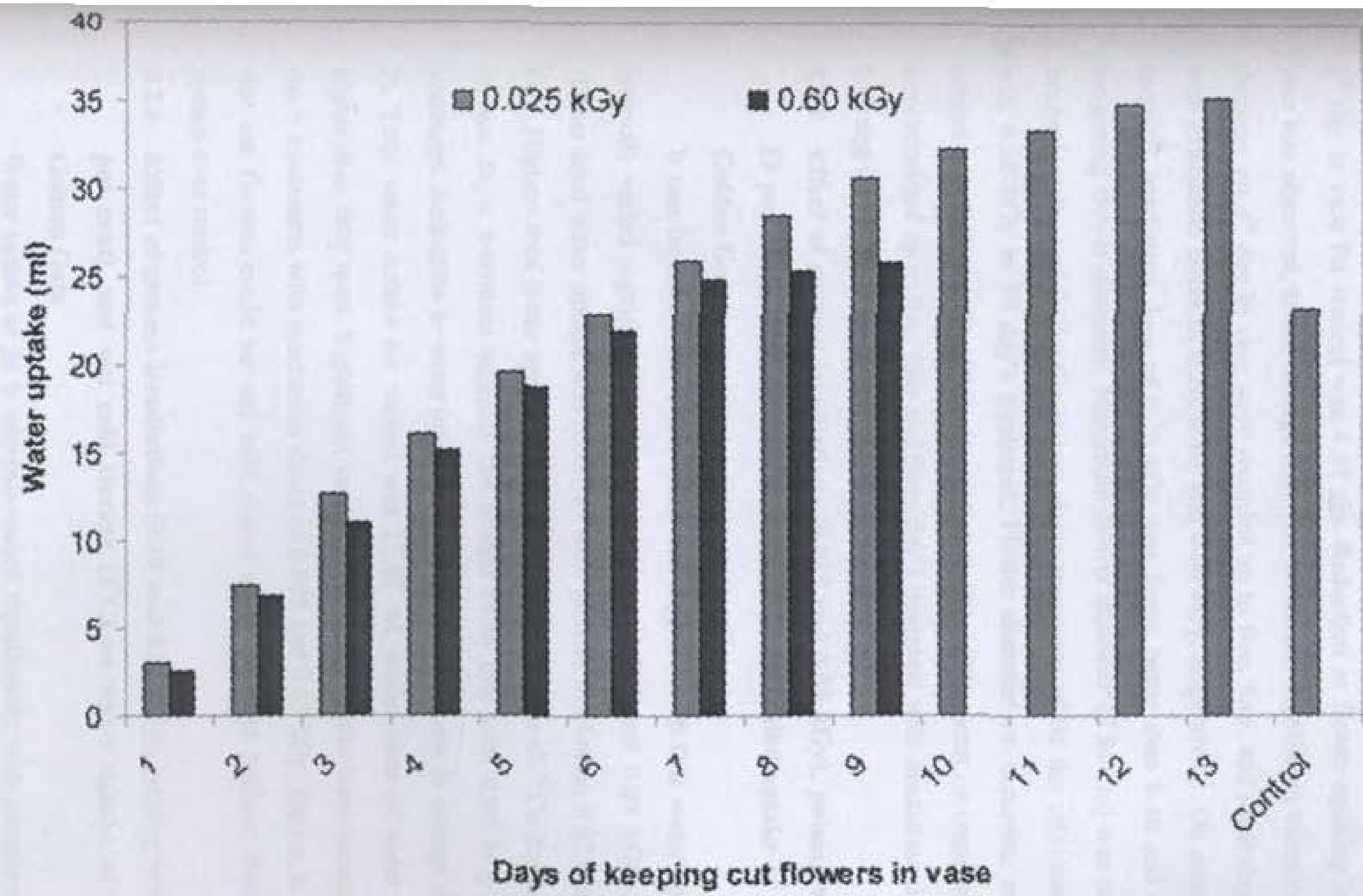

Fig. 2. Effect of gamma irradiation doses (0.025 and 0.60 kGy), pulsing with sucrose (3 %) and wet cold storage (2^0C) for two days on water uptake of cut rose cv. Golden Gate

than 0.40 and 0.60 kGy. On 3rd day in vase, maximum flower diameter (5.02 cm) was recorded with gamma rays 0.20 kGy in two day's treatment whereas the minimum (3.78 cm) with irradiation dose of 0.60 kGy in 10 day's treatment. Flower diameter on 3rd day in vase for control was 4.47 cm. Reduction in flower opening on 3rd day in vase was observed, as the storage duration increased. Significant variations in flower diameter on 3rd day in vase were recorded up to five, four, and three day's treatment with irradiation doses of 0.20, 0.40, and 0.60 kGy, respectively. On complete flower opening, irradiation dose of 0.20 kGy was found better than 0.40 and 0.60 kGy in increasing flower diameter. Maximum flower diameter (7.84 cm) was recorded with irradiation dose of 0.20 kGy in two day's treatment while the minimum (6.11 cm) with 0.60 kGy in 10 day's treatment. Flower diameter on complete expansion for control was 7.03 cm. Significant variations in flower diameter on complete expansion were recorded up to five, four and three day's treatment with irradiation doses of 0.20, 0.40 and 0.60 kGy, respectively.

4.2.5 Effect of gamma irradiations (0.025 and 0.05 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on water uptake of cut rose cv. Golden Gate

It can be seen from Table 4.2.5 and Appendix 26 that water uptake at 24 h intervals varied significantly with gamma rays 0.025 and 0.05 kGy over control. Higher total water uptake was recorded with gamma irradiation 0.025 kGy than 0.05 kGy. Highest total water uptake (34.95 ml) was recorded with ^{60}Co dose of 0.025 kGy in two day's treatment whereas the lowest (8.46 ml) with 0.05 kGy in 10 day's treatment. Reduction in water uptake was noted with increase in storage duration (Fig. 2). Total water uptake for control was 23.02 ml. Initial rates of water uptake were higher than later ones. Significant variations in water uptake were recorded up to six day's treatments with irradiation doses of 0.025 and 0.05 kGy. Hence, it is concluded that cut flowers could be wet cold stored up to six days without decline in water uptake over control.

4.2.6 Effect of gamma irradiations (0.10 and 0.20 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on water uptake of cut rose cv. Golden Gate

Water uptake at 24 h intervals varied significantly with gamma rays 0.10 and 0.20 kGy over control (Table 4.2.6 and Appendix 27). Highest total water uptake was

Table 4.2.7 Effect of gamma irradiations (0.40 and 0.60 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on water uptake of cut rose cv. Golden Gate (vase lives are given in Table 23)

Storage days	Water uptake (ml) in days after keeping cut flowers in vase (water)																			
	1		2		3		4		5		6		7		8		9		10	
	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60
2	2.75	2.61	7.10	6.84	12.18	11.10	15.48	15.16	19.04	18.70	22.17	21.90	25.08	24.76	27.85	25.28	28.61	25.66	29.95	
3	2.66	2.49	6.89	6.60	11.82	10.23	14.75	13.75	18.52	16.96	21.60	19.49	24.53	22.18	27.12	23.58	28.32	23.90	28.84	
4	2.47	2.32	6.76	6.38	10.54	10.07	13.86	13.49	17.04	16.65	19.59	19.20	22.27	20.05	24.84	20.37	25.23			
5	2.43	2.25	6.66	6.05	10.20	9.91	13.62	13.12	16.78	16.30	19.41	17.90	22.08	18.85	23.35		23.78			
6	2.34	2.17	6.40	5.78	9.81	9.57	13.22	12.80	16.34	16.04	19.21	16.82	20.04	17.32	20.47					
7	2.15	2.00	6.09	5.60	9.20	8.92	12.71	12.55	15.75	15.58	18.09	16.50	18.41	16.98						
8	2.04	1.92	5.72	5.42	8.57	8.44	11.94	11.78	14.41	12.30	15.03									
9	1.60	1.51	5.42	5.09	7.62	7.30	8.84	8.42	9.10	8.82										
10	1.37	1.28	3.61	4.71	6.12	6.82	7.18	7.30	7.46	7.86										
Control	2.36	2.36	6.38	6.38	9.78	9.78	13.08	13.08	16.20	16.20	18.70	18.70	21.33	21.33	23.02	23.02				
SEm±	0.034	0.031	0.116	0.067	0.166	0.118	0.235	0.194	0.252	0.213	0.285	0.200	0.302	0.211	0.215	0.169	0.246			
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**			
CD at 5%	0.098	0.092	0.338	0.196	0.485	0.344	0.685	0.565	0.735	0.622	0.831	0.584	0.881	0.615	0.626	0.493	0.718			

** = Highly significant

Table 4.2.8 **Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Mercedes**

Storage days	Changes in fresh weight (g)									Changes in dry weight (g)									Vase life (days)		
	After cold storage			On 3rd day in vase			On senescence day in vase			After cold storage			On 3rd day in vase			On senescence day in vase			0.025	0.05	0.10
	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10			
2	0.61	0.54	0.51	0.83	0.80	0.76	-0.18	-0.22	-0.24	0.13	0.11	0.11	0.17	0.17	0.16	-0.04	-0.05	-0.05	11.00	11.00	10.33
3	0.64	0.61	0.55	0.92	0.85	0.78	-0.47	-0.51	-0.55	0.14	0.13	0.12	0.19	0.18	0.16	-0.10	-0.11	-0.12	10.66	10.00	10.00
4	0.77	0.72	0.63	1.13	1.06	0.98	-0.58	-0.65	-0.69	0.16	0.15	0.14	0.24	0.22	0.21	-0.12	-0.14	-0.14	10.33	9.66	9.33
5	1.09	1.02	0.94	1.39	1.31	1.22	-0.73	-0.78	-0.85	0.23	0.22	0.19	0.29	0.28	0.26	-0.15	-0.16	-0.18	9.66	9.33	8.66
6	1.37	1.29	1.20	1.73	1.58	1.49	-0.89	-0.92	-0.98	0.29	0.27	0.25	0.37	0.34	0.32	-0.19	-0.19	-0.21	9.00	9.00	8.33
7	1.55	1.47	1.38	2.00	1.85	1.73	-0.97	-1.03	-1.08	0.33	0.31	0.29	0.42	0.39	0.37	-0.21	-0.22	-0.23	8.66	8.33	8.00
8	1.70	1.63	1.27	2.29	2.13	1.60	-1.09	-1.16	-1.23	0.36	0.35	0.27	0.49	0.45	0.34	-0.23	-0.25	-0.26	8.33	8.00	7.33
9	1.62	1.48	1.19	2.07	1.89	1.49	-1.27	-1.35	-1.43	0.34	0.31	0.25	0.44	0.40	0.32	-0.27	-0.29	-0.30	7.00	7.00	6.66
10	1.44	1.39	1.12	1.75	1.64	1.38	-1.44	-1.53	-1.61	0.39	0.29	0.24	0.37	0.35	0.29	-0.31	-0.32	-0.34	6.00	6.00	6.00
Control	-	-	-	0.42	0.42	0.42	-1.98	-1.98	-1.98	-	-	-	0.09	0.09	0.09	-0.41	-0.41	-0.41	7.66	7.66	7.66
SEm±	0.190	0.014	0.012	0.024	0.014	0.023	0.013	0.017	0.014	0.004	0.004	0.004	0.005	0.004	0.004	0.003	0.003	0.004	0.111	0.108	0.115
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
CD at 5%	0.076	0.041	0.035	0.072	0.042	0.069	0.039	0.050	0.043	0.012	0.011	0.011	0.015	0.011	0.012	0.008	0.009	0.012	0.327	0.318	0.325

- Indicates loss in fresh/dry weight over the fresh/dry weight at harvest
** = Highly significant

recorded with gamma rays 0.10 kGy than 0.20 kGy. Highest total water uptake (32.25 ml) was recorded with gamma rays 0.10 kGy in two day's treatment whereas the lowest (7.40 ml) with 0.20 kGy in 10 day's treatment. Reduction in water uptake was noted with increase in storage duration. Total water uptake for control was 23.02 ml. Significant variations in water uptake at different intervals were recorded up to six and five day's treatments with irradiation doses of 0.10 and 0.20 kGy, respectively. Hence, it is concluded that increased water uptake with irradiation dose of 0.10 kGy enhanced the vase life and intrinsic quality of cut flowers.

4.2.7 Effect of gamma irradiations (0.40 and 0.60 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on water uptake of cut rose cv. Golden Gate

Data presented in Table 4.2.7 and Appendix 28 clearly indicate that water uptake at 24 h intervals varied significantly with gamma irradiation doses of 0.40 and 0.60 kGy over control. Reduction in water uptake was noted with increase in storage duration. With respect to water uptake, gamma irradiation 0.40 kGy was found better than 0.60 kGy. Highest total water uptake (29.95 ml) was recorded with irradiation dose of 0.40 kGy in two day's treatment whereas the lowest (7.86 ml) with 0.60 kGy in 10 day's treatment. Total water uptake for control was 23.02 ml. Significant variations in water uptake at different days were recorded up to four and three day's treatments with gamma rays of 0.40 and 0.60 kGy, respectively. Thus it is concluded that irradiation dose of 0.40 kGy is better than 0.60 kGy.

4.2.8 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Mercedes

Perusal of Table 4.2.8 and Appendix 29 reveals that changes in fresh and dry weights after cold storage, on 3rd day in vase, and on senescence day in vase and vase life varied significantly with gamma irradiation doses of 0.025, 0.05, and 0.10 kGy over control. After cold storage, gamma irradiation 0.025 kGy was found better than 0.05 and 0.10 kGy in respect of gain in fresh weight on different treatments. After cold storage, gain in fresh weights in increasing order was recorded up to eight day's treatments with irradiation doses of 0.025 and 0.05 kGy and up to seven days with 0.10 kGy. After cold storage, maximum gain in fresh weight (1.70 g) was recorded with gamma irradiation dose of 0.025 kGy in eight day's treatment whereas the

Table 4.2.9 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Mercedes

Storage days	Changes in fresh weight (g)									Changes in dry weight (g)									Vase life (days)		
	After cold storage			On 3rd day in vase			On senescence day in vase			After cold storage			On 3rd day in vase			On senescence day in vase			0.20	0.40	0.60
	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60			
2	0.46	0.39	0.34	0.73	0.68	0.60	-0.26	-0.27	-0.29	0.10	0.08	0.07	0.15	0.14	0.13	-0.05	-0.06	-0.06	9.66	9.33	8.66
3	0.52	0.45	0.40	0.76	0.70	0.66	-0.59	-0.64	-0.68	0.11	0.09	0.08	0.16	0.15	0.14	-0.12	-0.14	-0.14	9.33	9.00	8.33
4	0.55	0.49	0.35	0.92	0.85	0.61	-0.75	-0.82	-0.86	0.12	0.10	0.07	0.19	0.18	0.13	-0.16	-0.17	-0.18	8.66	8.66	7.66
5	0.87	0.81	0.29	1.12	1.08	0.54	0.92	-0.97	-1.02	0.18	0.17	0.06	0.24	0.23	0.11	-0.19	-0.21	-0.22	8.33	8.00	7.00
6	1.13	0.75	0.24	1.38	0.89	0.49	-1.05	-1.14	-1.22	0.24	0.16	0.05	0.29	0.19	0.10	-0.22	-0.24	-0.26	8.00	7.33	6.66
7	1.04	0.68	0.21	1.25	0.78	0.42	-1.17	-1.25	-1.29	0.22	0.14	0.04	0.26	0.16	0.09	-0.25	-0.26	-0.27	7.33	6.66	6.33
8	0.96	0.62	0.16	1.17	0.70	0.35	-1.32	-1.42	-1.51	0.20	0.13	0.03	0.25	0.15	0.07	-0.28	-0.30	-0.32	6.33	6.00	5.66
9	0.85	0.57	0.11	1.08	0.67	0.30	-1.54	-1.65	-1.73	0.18	0.12	0.02	0.23	0.14	0.06	-0.33	-0.35	-0.37	6.00	5.33	5.00
10	0.72	0.50	0.09	0.99	0.59	0.26	-1.73	-1.84	-1.92	0.15	0.11	0.02	0.21	0.12	0.05	-0.37	-0.39	-0.41	5.66	4.66	4.33
Control	-	-	-	0.42	0.42	0.42	-1.98	-1.98	-1.98	-	-	-	0.09	0.09	0.09	-0.41	-0.41	-0.41	7.66	7.66	7.66
SEm±	0.013	0.011	0.004	0.017	0.012	0.008	0.023	0.016	0.017	0.003	0.002	0.001	0.004	0.002	0.001	0.004	0.004	0.005	0.096	0.112	0.105
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
CD at 5%	0.037	0.031	0.012	0.049	0.036	0.023	0.069	0.048	0.049	0.009	0.006	0.002	0.011	0.006	0.004	0.013	0.011	0.016	0.285	0.322	0.310

- Indicates loss in fresh/dry weight over the fresh/dry weight at harvest
** = Highly significant

minimum (0.51 g) with 0.10 kGy in two day's treatment. On 3rd day in vase, maximum gain in fresh weight (2.29 g) was recorded with ^{60}Co 0.025 kGy dose in eight day's treatment. Gain in fresh weight on 3rd day in vase for control was 0.42 g. On 3rd day in vase gain in fresh weight in increasing order was recorded up to eight day's treatments with ^{60}Co doses of 0.025 and 0.05 kGy and up to seven day's with 0.10 kGy. Minimum loss in fresh weight (-0.18 g) on senescence day in vase was observed with gamma rays 0.025 kGy in two day's treatment whereas the maximum (-1.61 g) with 0.10 kGy in 10 day's treatment. Loss in fresh weight on senescence day in vase for control was -1.98 g. Loss in fresh weights in increasing order with all the three doses were noted with increase in storage duration. Corresponding changes in dry weights at various stages of postharvest life of cut flowers were also noted. Vase life was recorded maximum with ^{60}Co 0.025 kGy dose than 0.05 and 0.10 kGy. Maximum vase life (11.00 days) was recorded with gamma rays 0.025 and 0.05 kGy in two day's treatment whereas the minimum (6.00 days) with all the three doses in 10 day's treatment. Reduction in vase life was noted with increase in storage duration. Vase life value for control was 7.66 days. Significant variations in vase life of cut 'Mercedes' rose were recorded up to eight days with irradiation doses 0.025 and 0.05 kGy and up to seven days with 0.10 kGy.

4.2.9 Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Mercedes

Table 4.2.9 and Appendix 30 indicate that changes in fresh and dry weights after cold storage, on 3rd day in vase, and on senescence day in vase, and vase life varied significantly with gamma irradiation dose of 0.20, 0.40, and 0.60 kGy over control. After cold storage maximum gain in fresh weight was recorded with gamma rays 0.20 kGy than 0.40 and 0.60 kGy. After cold storage maximum gain in fresh weight (1.13 g) was recorded with gamma rays 0.20 kGy in six day's treatment whereas the minimum (0.09 g) with 0.60 kGy in 10 day's treatment. Gain in fresh weights in increasing order after cold storage were recorded up to six, five and three day's treatments with gamma irradiation doses of 0.20, 0.40, and 0.60 kGy, respectively. On 3rd day in vase, maximum gain in fresh weight (1.38 g) was recorded with gamma rays 0.20 kGy in six day's treatment whereas the minimum (0.26 g) with 0.60 kGy in 10 day's treatment. Gain in fresh weight in increasing order was recorded

Table 4.2.10 **Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2°C) on flower quality of cut rose cv. Mercedes (vase lives are given in Table 29)**

Storage days	Flower diameter (cm)											
	At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
2	1.43	1.40	1.44	2.91	2.88	2.82	4.94	4.89	4.82	7.56	7.51	7.48
3	1.43	1.45	1.40	3.05	3.00	2.95	4.88	4.82	4.76	7.44	7.42	7.37
4	1.42	1.46	1.44	3.12	3.06	2.99	4.79	4.74	4.62	7.35	7.24	7.15
5	1.43	1.39	1.39	3.28	3.23	3.16	4.72	4.68	4.54	7.24	7.16	7.06
6	1.39	1.38	1.38	3.40	3.36	3.28	4.65	4.55	4.46	7.17	7.03	6.97
7	1.45	1.41	1.45	3.52	3.47	3.41	4.57	4.47	4.41	7.08	7.95	6.90
8	1.39	1.40	1.43	3.65	3.59	3.50	4.46	4.40	4.24	6.97	6.91	6.77
9	1.45	1.42	1.44	3.72	3.70	3.59	4.30	4.29	4.17	6.73	6.67	6.70
10	1.44	1.39	1.40	3.81	3.74	3.65	4.27	4.18	4.11	6.64	6.56	6.63
Control	1.42	1.42	1.42	-	-	-	4.14	4.14	4.14	6.55	6.55	6.55
SEm±	0.015	0.026	0.022	0.050	0.053	0.053	0.057	0.074	0.083	0.087	0.116	0.086
F test	NS	NS	NS	**	**	**	**	**	**	**	**	**
CD at 5%	-	-	-	0.148	0.156	0.172	0.167	0.219	0.246	0.258	0.342	0.254

NS = Non significant
** = Highly significant

up to six, five and three day's treatments with irradiation doses of 0.20, 0.40, and 0.60 kGy, respectively. Minimum loss in fresh weight (-0.26 g) was observed with gamma rays 0.20 kGy in two day's treatment whereas the maximum (-1.92 g) with 0.60 kGy in 10 day's treatment. Increase in fresh weight loss on senescence day in vase was recorded with increase in storage duration. Loss in fresh weight on senescence day in vase for control was -1.98 g. Corresponding changes in dry weights at aforementioned stages of vase life evaluation were also noted. Maximum vase life (9.66 days) was recorded with gamma irradiation dose of 0.20 kGy in two day's treatment whereas the minimum (4.33 days) with 0.60 kGy in 10 day's treatment. Decline in vase life was observed with increase in storage duration. Vase life value for control was 7.66 days. Significant variations in vase life were recorded up to six, five, and three day's treatments with irradiation doses of 0.20, 0.40, and 0.60 kGy, respectively.

4.2.10 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on flower quality of cut rose cv. Mercedes

Flower diameter after cold storage, on 3rd day in vase, and on complete flower expansion varied significantly with gamma rays 0.025, 0.05, and 0.10 kGy over control (Table 4.2.10 and Appendix 31). Flower diameter at harvest varied non-significantly. After cold storage, increase in flower diameter was recorded with increase in storage duration. After cold storage maximum flower diameter (3.81 cm) was recorded with gamma rays dose of 0.025 kGy in 10 day's treatment whereas the minimum (2.82 cm) with 0.10 kGy in two day's treatment. On 3rd day in vase, maximum flower diameter (4.94 cm) was recorded with gamma rays dose of 0.025 kGy in two day's treatment whereas the minimum (4.11 cm) with 0.10 kGy in 10 day's treatment. Significant variations in flower diameter on 3rd day in vase were recorded up to eight day's treatments with gamma irradiation 0.025 and 0.05 kGy and up to seven day's treatments with 0.10 kGy. On complete flower expansion decrease in flower diameter with all the three doses was noted as the storage duration increased. On complete flower expansion maximum flower diameter (7.56 cm) was recorded with gamma rays 0.025 kGy in two day's treatment whereas the minimum (6.63 cm) with 0.10 kGy in 10 day's treatment. Flower diameter on complete expansion for control was 6.55 cm. Significant variations in flower diameter on

Table 4.2.11 **Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on flower quality of cut rose cv. Mercedes (vase lives are given in Table 30)**

Storage days	Flower diameter (cm)											
	At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
2	1.40	1.40	1.39	2.78	2.74	2.68	4.77	4.72	4.60	7.42	7.37	7.25
3	1.42	1.42	1.45	2.90	2.85	2.77	4.62	4.55	4.41	7.33	7.19	6.99
4	1.45	1.44	1.43	2.96	2.91	2.85	4.55	4.46	4.20	7.18	7.08	6.70
5	1.39	1.43	1.42	3.09	3.02	2.94	4.47	4.39	4.15	7.10	6.96	6.61
6	1.38	1.45	1.41	3.20	3.12	3.05	4.40	4.32	4.09	7.00	6.80	6.52
7	1.44	1.39	1.43	3.33	3.26	3.14	4.28	4.28	4.05	6.79	6.69	6.45
8	1.45	1.41	1.44	3.45	3.39	3.30	4.17	4.14	3.99	6.70	6.61	6.39
9	1.43	1.43	1.43	3.51	3.45	3.35	4.11	4.06	3.95	6.58	6.50	6.36
10	1.40	1.42	1.42	3.58	3.50	3.44	4.06	3.97	3.90	6.50	6.42	6.32
Control	1.42	1.42	1.42	-	-	-	4.14	4.14	4.14	6.55	6.55	6.55
SEm±	0.022	0.022	0.027	0.057	0.048	0.047	0.082	0.072	0.078	0.142	0.090	0.082
F test	NS	NS	NS	**	**	**	**	**	**	**	**	**
CD at 5%	-	-	-	0.169	0.143	0.140	0.241	0.213	0.230	0.420	0.265	0.241

NS = Non significant
** = Highly significant

Table 4.2.12 Effect of gamma irradiations (0.025 and 0.05 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on water uptake of cv. Mercedes (vase lives are given in Table 29)

Storage days	Water uptake (ml) in days after keeping cut flowers in vase (water)																							
	1		2		3		4		5		6		7		8		9		10		11		12	
	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05
2	2.87	2.80	7.20	7.12	12.37	12.15	15.78	15.62	19.40	19.24	22.66	22.52	25.51	25.35	28.05	27.90	30.20	30.12	31.15	31.02	31.80	31.48		
3	2.81	2.76	7.13	7.03	12.20	12.08	15.47	15.21	19.15	18.92	22.39	22.27	25.30	25.16	27.81	27.65	29.96	29.73	30.27	30.08	30.52			
4	2.75	2.69	6.92	6.85	11.33	11.20	14.60	14.45	17.78	17.62	21.31	21.16	24.06	23.81	27.12	25.62	28.80	26.12	29.55	26.43	29.87			
5	2.59	2.54	6.83	6.79	11.02	10.87	14.45	14.22	17.40	17.20	20.92	20.65	23.71	23.52	26.82	25.13	28.34	25.84	28.70	26.14				
6	2.43	2.41	6.75	6.72	10.90	10.58	14.20	13.96	17.12	16.95	20.35	20.28	23.26	23.11	25.17	24.59	25.85	24.87						
7	2.36	2.35	6.66	6.65	10.75	10.43	14.06	13.82	16.96	16.73	20.14	19.97	22.84	22.63	24.23	23.15	24.49	23.42						
8	2.25	2.20	6.62	6.56	10.51	10.32	13.89	13.70	16.78	16.62	19.83	19.70	22.23	22.95	22.55	22.41	22.80							
9	2.09	1.97	6.35	6.29	10.04	9.85	12.60	12.42	15.31	13.90	16.55	14.56	17.12	14.92										
10	1.84	1.80	5.99	5.90	9.51	9.36	11.89	11.75	14.68	12.72	15.20	13.17												
Control	2.03	2.03	6.13	6.13	9.55	9.55	12.80	12.80	15.72	15.72	18.39	18.39	21.04	21.04	21.30	21.30								
SEm±	0.046	0.045	0.125	0.101	0.178	0.165	0.217	0.260	0.281	0.263	0.372	0.298	0.354	0.341	0.376	0.274	0.440	0.387	0.359					
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**					
CD at 5%	0.134	0.132	0.369	0.298	0.525	0.487	0.639	0.766	0.83	0.777	1.097	0.818	1.045	1.005	1.110	0.899	1.297	1.142	1.059					

** = Highly significant

complete opening were recorded up to eight day's treatments with gamma irradiation 0.025 and 0.05 kGy and up to seven days with 0.10 kGy.

4.2.11 Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on flower quality of cut rose cv. Mercedes

It is evident from Table 4.2.11 and Appendix 32 that flower diameter after cold storage, on 3rd day in vase, and on complete expansion varied significantly with gamma rays 0.20, 0.40 and 0.60 kGy over control. Non-significant variations in flower diameter were recorded at harvest. During cold storage, increase in flower diameter was noted with increase in storage duration. After cold storage maximum flower diameter (3.58 cm) was recorded with gamma rays dose of 0.20 kGy in 10 day's treatment whereas the minimum (2.68 cm) with 0.60 kGy in two day's treatment. On 3rd day in vase, maximum flower diameter was noted with ^{60}Co 0.20 kGy dose than 0.40 and 0.60 kGy. On 3rd day in vase, maximum flower diameter (4.77 cm) was recorded with gamma rays 0.20 kGy in two day's treatment whereas the minimum (3.90 cm) with 0.60 kGy in 10 day's treatment. Flower diameter on 3rd day in vase for control was 4.14 cm. Significant variations in flower diameter on 3rd day in vase were recorded up to six, five, and four day's treatments with gamma rays 0.20, 0.40, and 0.60 kGy, respectively. On complete flower expansion, decrease in flower diameter was recorded with increase in storage duration. Flower diameter on complete expansion for control was 6.55 cm. Maximum flower diameter (7.42 cm) was recorded with gamma rays 0.20 kGy in two day's treatment whereas the minimum (6.32 cm) with 0.60 kGy in 10 day's treatment. Significant variations in flower diameter on complete opening were observed up to six, five and three day's treatments with ^{60}Co doses 0.20, 0.40, and 0.60 kGy, respectively. Hence, it is concluded that cut flowers after treatment with 0.20 kGy and pulsing with sucrose could be wet cold stored for six days without decline in flower diameter over fresh cut flowers.

4.2.12 Effect of gamma irradiations (0.025 and 0.05 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on water uptake of cut rose cv. Mercedes

Table 4.2.12 and Appendix 33 reveal that water uptake at 24 h intervals varied significantly with gamma rays doses of 0.025 and 0.05 kGy over control. Highest total

Table 4.2.13 Effect of gamma irradiations (0.10 and 0.20 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on water uptake of cut rose cv. Mercedes (vase lives are given in Tables 29 and 30)

Storage days	Water uptake (ml) in days after keeping cut flowers in vase (water)																				
	1		2		3		4		5		6		7		8		9		10		11
	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10
2	2.74	2.69	7.03	6.91	12.07	11.93	15.43	15.32	19.13	19.00	22.35	22.16	25.14	24.90	27.72	26.12	29.95	26.78	30.28	27.13	30.75
3	2.68	2.52	6.92	6.75	12.00	11.75	15.06	15.00	18.71	18.62	22.09	21.92	25.01	24.66	27.55	25.03	28.10	25.75	28.42	26.07	
4	2.54	2.39	6.62	6.55	10.95	10.90	14.27	14.63	17.42	17.35	20.90	21.14	23.89	24.25	24.90	24.80	25.36	25.26	25.78		
5	2.45	2.31	6.57	6.46	10.80	10.45	14.03	13.95	17.13	16.93	20.35	20.50	23.45	23.42	24.52	24.25	24.78	24.63			
6	2.38	2.25	6.53	6.41	10.47	10.25	13.81	13.60	16.89	16.70	19.89	19.65	22.90	22.80	23.39	23.19	23.67				
7	2.23	1.99	6.48	6.28	10.24	10.04	13.57	12.93	16.65	16.25	19.50	18.16	22.35	19.05	22.85	19.38					
8	2.08	1.85	6.29	5.95	9.81	9.90	12.17	12.25	16.10	14.10	17.66	14.45	18.19	14.86	18.45						
9	1.90	1.73	6.07	5.78	9.42	9.35	11.88	11.67	13.27	13.66	14.90	13.97	15.36								
10	1.72	1.62	5.82	5.69	9.18	9.02	11.47	11.23	12.08	11.85	12.43	12.37									
Control	2.03	2.03	6.13	6.13	9.55	9.55	12.80	12.80	15.72	15.72	18.39	18.39	21.04	21.04	21.30	21.30					
SEm±	0.035	0.035	0.106	0.078	0.161	0.170	0.167	0.207	0.271	0.303	0.313	0.281	0.392	0.245	0.333	0.381	0.284	0.304			
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**			
CD at 5%	0.183	0.185	0.312	0.230	0.474	0.501	0.492	0.609	0.799	0.894	0.922	0.828	1.158	0.723	1.040	1.125	0.839	0.897			

** = Highly significant

Table 4.2.14 Effect of gamma irradiations (0.40 and 0.60 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on water uptake of cut rose cv. Mercedes (vase lives are given in Table 30)

Storage days	Water uptake (ml) in days after keeping cut flowers in vase (water)																	
	1		2		3		4		5		6		7		8		9	
	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60
2	2.59	2.40	6.72	6.65	11.80	11.55	15.11	14.90	18.78	18.53	22.07	21.70	24.75	23.78	26.01	24.26	26.57	24.53
3	2.37	2.27	6.65	6.51	11.22	10.30	14.82	14.00	18.02	17.10	21.66	20.21	24.17	22.15	25.52	22.90	25.82	23.27
4	2.26	2.09	6.58	6.36	10.70	10.01	14.02	13.21	17.70	16.22	20.83	19.00	23.62	21.83	24.37	22.05	24.58	
5	2.17	1.97	6.50	6.22	10.15	9.82	13.61	13.16	16.65	16.76	20.15	17.80	23.00	18.36	23.55			
6	2.03	1.85	6.29	6.07	10.02	9.27	13.32	12.75	16.34	15.30	19.80	16.21	20.39	16.55	20.68			
7	1.94	1.73	6.07	5.81	9.85	9.05	13.04	12.26	15.90	14.37	16.43	15.81	16.84	15.40				
8	1.79	1.66	5.90	5.62	9.60	8.83	12.75	10.55	14.31	11.21	14.80	11.63						
9	1.65	1.53	5.74	5.43	9.26	8.65	12.14	9.70	12.65	10.14	12.91							
10	1.56	1.42	5.60	5.35	8.85	8.39	11.03	9.25	11.39	9.63								
Control	2.03	2.03	6.13	6.13	9.55	9.55	12.80	12.80	15.72	15.72	18.39	18.39	21.04	21.04	21.30	21.30		
SEm±	0.039	0.029	0.117	0.114	0.190	0.180	0.204	0.234	0.242	0.283	0.220	0.244	0.229	0.286	0.274	0.269		
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**		
CD at 5%	0.114	0.087	0.344	0.335	0.561	0.531	0.601	0.691	0.713	0.833	0.650	0.720	0.675	0.842	0.810	0.795		

** = Highly significant

water uptake was recorded with gamma rays 0.025 kGy than 0.05 kGy. Initial water uptake rate was higher than latter one. Highest total water uptake (31.80 ml) was recorded with gamma rays dose of 0.025 kGy in two day's treatment whereas the lowest (13.17 ml) with 0.05 kGy in 10 day's treatment. Total water uptake for control was 21.30 ml. With both irradiation doses, decline in water uptake was noted as the storage duration increased. Significant variations in water uptake were recorded up to eight day's treatments with both gamma rays doses. Hence, it is highlighted that increased water uptake with both doses manifested in enhanced vase life of 'Mercedes' cut rose.

4.2.13 Effect of gamma irradiations (0.10 and 0.20 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on water uptake of cut rose cv. Mercedes

Water uptake on different days varied significantly with gamma rays 0.10 and 0.20 kGy over control (Table 4.2.13 and Appendix 34). Decline in water uptake was recorded with increase in storage duration. Increase in water uptake with decreasing rate was recorded as the cut flowers progressed towards senescence. Total water uptake for control was 21.30 ml. Highest total water uptake (30.95 ml) was recorded with gamma rays dose of 0.10 kGy in two day's treatment whereas the lowest (12.37 ml) with 0.20 kGy in 10 day's treatment. Significant variations in water uptake were recorded up to seven and six day's treatments with gamma irradiation doses of 0.10 and 0.20 kGy, respectively. Hence, it is concluded that higher water uptake with gamma rays dose 0.10 kGy resulted in increased vase life and quality of cut flowers than that of 0.20 kGy.

4.2.14 Effect of gamma irradiations (0.40 and 0.60 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on water uptake of cut rose cv. Mercedes

It is evident from Table 4.2.14 and Appendix 35 that water uptake at 24 h intervals varied significantly with gamma irradiation doses 0.40 and 0.60 kGy over control. Highest total water uptake (26.57 ml) was recorded with gamma rays dose of 0.40 kGy in two day's treatment whereas the lowest (9.63 ml) with 0.60 kGy in 10 day's treatment. Total water uptake value for control was 21.30 ml. Decline in water uptake was noted with increase in storage duration. Initial rates of water uptake with both the doses were higher than the latter ones. Significant variations in water uptake

Table 4.2.15 **Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^{0}C) on changes in fresh and dry weights, and vase lives of cut rose cv. Noblesse**

Storage days	Changes in fresh weight (g)									Changes in dry weight (g)									Vase life (days)		
	After cold storage			On 3rd day in vase			On senescence day in vase			After cold storage			On 3rd day in vase			On senescence day in vase			0.025	0.05	0.10
	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10			
2	0.69	0.63	0.60	0.88	0.84	0.78	-0.21	-0.24	-0.27	0.15	0.13	0.13	0.19	0.18	0.16	-0.04	-0.05	-0.06	12.00	12.00	11.33
3	0.82	0.78	0.72	0.97	0.90	0.86	-0.58	-0.62	-0.68	0.17	0.16	0.15	0.21	0.19	0.18	-0.12	-0.13	-0.14	12.00	11.66	11.00
4	1.08	1.01	0.97	1.20	1.12	1.05	-0.60	-0.65	-0.74	0.23	0.21	0.21	0.25	0.24	0.22	-0.13	-0.14	-0.16	11.33	10.00	9.66
5	1.31	1.23	1.15	1.45	1.39	1.28	-0.83	-0.90	-0.99	0.28	0.26	0.24	0.31	0.29	0.27	-0.18	-0.19	-0.21	10.66	9.66	9.00
6	1.62	1.55	1.40	1.86	1.79	1.63	-0.95	-1.02	-1.13	0.34	0.33	0.30	0.39	0.38	0.35	-0.20	-0.22	-0.24	9.33	9.00	8.66
7	1.83	1.76	1.28	2.05	1.98	1.54	-1.02	-1.10	-1.22	0.39	0.37	0.27	0.43	0.42	0.33	-0.22	-0.23	-0.26	9.00	8.66	8.33
8	1.56	1.50	1.20	1.77	1.71	1.33	-1.13	-1.22	-1.30	0.33	0.32	0.25	0.37	0.36	0.28	-0.24	-0.26	-0.28	7.66	7.00	7.00
9	1.30	1.21	1.12	1.50	1.42	1.23	-1.35	-1.44	-1.56	0.27	0.26	0.24	0.32	0.30	0.26	-0.29	-0.31	-0.33	6.00	6.00	5.66
10	1.14	1.09	1.02	1.29	1.20	1.12	-1.52	-1.63	-1.72	0.24	0.23	0.22	0.27	0.25	0.24	-0.32	-0.35	-0.36	5.66	5.66	5.33
Control	-	-	-	0.47	0.47	0.47	-2.08	-2.08	-2.08	-	-	-	0.11	0.11	0.11	-0.44	-0.44	-0.44	8.33	8.33	8.33
SEm±	0.023	0.019	0.017	0.027	0.025	0.019	0.020	0.020	0.019	0.004	0.004	0.004	0.005	0.004	0.004	0.003	0.004	0.005	0.180	0.102	0.113
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
CD at 5%	0.069	0.056	0.049	0.078	0.075	0.056	0.058	0.060	0.055	0.013	0.012	0.010	0.014	0.012	0.011	0.009	0.011	0.015	0.532	0.230	0.251

- Indicates loss in fresh/dry weight over the fresh/dry weight at harvest
** = Highly significant

at different days were recorded up to five and three day's treatments with gamma rays 0.40 and 0.60 kGy, respectively. Lower water uptake with irradiation dose of 0.60 kGy resulted in reduced vase life of cut flowers.

4.2.15 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Noblesse

Perusal of Table 4.2.15 and Appendix 36 indicates that changes in fresh and dry weights after cold storage, on 3rd day in vase, and on senescence day in vase, and vase life varied significantly with gamma rays 0.025, 0.05, and 0.10 kGy over control. After cold storage, maximum gain in fresh weight (1.83 g) was recorded with gamma rays 0.025 kGy in seven day's treatment whereas the minimum (0.60 g) with 0.10 in two day's treatment. Gamma rays 0.025 kGy was found better than 0.05 and 0.10 kGy in terms of gain in fresh weight after cold storage. Gain in fresh weights in increasing order after cold storage was recorded up to seven day's treatments with gamma doses 0.025 and 0.05 kGy and up to six day's treatments with 0.10 kGy. On 3rd day in vase, maximum gain in fresh weight (2.05 g) was recorded with gamma dose 0.025 kGy in seven day's treatment whereas the minimum (0.78 g) with 0.10 kGy in two day's treatment. Maximum gain in fresh weight on 3rd day in vase was recorded with gamma dose 0.025 kGy followed by 0.05 and 0.10 kGy. Gain in fresh weight in increasing order on 3rd day in vase was recorded up to seven day's treatments with ^{60}Co doses 0.025 and 0.05 kGy and up to six day's treatments with 0.10 kGy. On 3rd day in vase, gain in fresh weight for control was 0.47 g. On senescence day in vase minimum loss in fresh weight (-0.21 g) was recorded with gamma dose 0.025 kGy in two day's treatment whereas the maximum (-1.72 g) with 0.10 kGy in 10 day's treatment. Loss in fresh weight on 3rd day in vase for control was -2.08 g. On senescence day in vase minimum loss in fresh weight was recorded in two day's treatment whereas the maximum in 10 day's treatment with all the three doses. Corresponding changes in dry weights were also recorded. Gamma irradiation 0.025 kGy was found best followed by 0.05 and 0.10 kGy with respect to increase in vase life. Maximum vase life (12.00 days) was recorded with gamma doses 0.025 and 0.05 kGy in two days treatment whereas the minimum (5.33 days) with 0.10 kGy in 10 day's treatment. Decline in vase life was noted with increase in storage duration. Vase life for control was 8.33 days. Significant variations in vase life were recorded up to

Table 4.2.16 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2°C) on changes in fresh and dry weights, and vase lives of cut rose cv. Noblesse

Storage days	Changes in fresh weight (g)									Changes in dry weight (g)									Vase life (days)		
	After cold storage			On 3rd day in vase			On senescence day in vase			After cold storage			On 3rd day in vase			On senescence day in vase			0.20	0.40	0.60
	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60			
2	0.54	0.48	0.45	0.72	0.68	0.66	-0.31	-0.34	-0.37	0.11	0.10	0.09	0.15	0.14	0.14	-0.06	-0.07	-0.08	10.33	9.66	9.33
3	0.66	0.61	0.57	0.80	0.75	0.71	-0.72	-0.74	-0.76	0.14	0.13	0.12	0.17	0.16	0.15	-0.15	-0.16	-0.16	10.00	9.00	9.00
4	0.91	0.85	0.49	1.02	0.97	0.65	-0.82	-0.85	-0.89	0.19	0.18	0.10	0.22	0.21	0.14	-0.17	-0.18	-0.19	9.33	8.66	8.00
5	1.09	0.77	0.43	1.22	0.86	0.58	-1.14	-1.21	-1.28	0.23	0.16	0.09	0.26	0.18	0.12	-0.24	-0.26	-0.27	8.66	8.00	7.66
6	0.99	0.68	0.36	1.07	0.73	0.50	-1.35	-1.43	-1.52	0.21	0.14	0.07	0.23	0.15	0.10	-0.29	-0.30	-0.32	7.33	7.00	7.00
7	0.90	0.58	0.30	0.98	0.65	0.43	-1.54	-1.66	-1.70	0.19	0.12	0.06	0.21	0.14	0.09	-0.33	-0.35	-0.36	6.66	6.33	6.66
8	0.82	0.49	0.25	0.90	0.56	0.38	-1.66	-1.73	-1.82	0.17	0.10	0.05	0.19	0.12	0.08	-0.35	-0.37	-0.39	6.00	5.66	6.33
9	0.72	0.37	0.18	0.83	0.44	0.34	-1.74	-1.86	-1.93	0.15	0.08	0.04	0.18	0.09	0.07	-0.37	-0.39	-0.41	5.33	5.33	5.00
10	0.67	0.30	0.13	0.72	0.35	0.29	-1.85	-1.97	-2.02	0.14	0.06	0.03	0.15	0.07	0.06	-0.39	-0.42	-0.43	5.00	5.00	4.66
Control	-	-	-	0.47	0.47	0.47	-2.08	-2.08	-2.08	-	-	-	0.11	0.11	0.11	-0.44	-0.44	-0.44	8.33	8.33	8.33
SEm±	0.015	0.009	0.006	0.017	0.007	0.006	0.021	0.025	0.023	0.003	0.002	0.001	0.002	0.002	0.001	0.004	0.005	0.005	0.088	0.104	0.091
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
CD at 5%	0.043	0.026	0.017	0.051	0.021	0.019	0.063	0.075	0.068	0.008	0.005	0.002	0.007	0.005	0.004	0.011	0.016	0.014	0.247	0.294	0.268

- Indicates loss in fresh/dry weight over the fresh/dry weight at harvest

** = Highly significant

seven day's treatments with gamma doses 0.025 and 0.05 kGy and up to six days with 0.10 kGy. Hence, it is concluded that cut 'Noblesse' flowers after subjecting to gamma rays treatment with 0.025 or 0.05 kGy and pulsing with sucrose could be wet cold stored for seven days without affecting vase life over fresh cut flowers.

4.2.16 Effect of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Noblesse

Data presented in Table 4.2.16 and Appendix 37 indicate that changes in fresh and dry weights after cold storage, on 3rd day in vase, and on senescence day in vase, and vase life varied significantly with gamma doses 0.20, 0.40, and 0.60 kGy over control. After cold storage, maximum gain in fresh weight (1.09 g) was recorded with 0.025 kGy in five day's treatment whereas the minimum (0.13 g) with 0.60 kGy in 10 day's treatment. After cold storage, gain in fresh weight in increasing order was recorded up to five, four, and three day's treatments with gamma doses of 0.20, 0.40, and 0.60 kGy, respectively. On 3rd day in vase, maximum gain in fresh weight (1.22 g) was recorded with gamma dose 0.20 kGy in five day's treatment whereas the minimum (0.29 g) with 0.60 kGy in 10 day's treatment. On 3rd day in vase, gamma dose 0.20 kGy was found best in terms of gain in fresh weight followed by 0.40 and 0.60 kGy. Gain in fresh weight on 3rd day in vase for control was 0.47 g. On senescence day in vase, minimum loss in fresh weight (-0.31 g) was recorded with gamma dose 0.20 kGy in two day's treatment whereas the maximum (-2.02 g) with 0.60 kGy in 10 day's treatment. Increase in loss of fresh weight on senescence day in vase was noted with increase in storage duration. Loss in fresh weight on senescence day in vase for control was -2.08 g. Corresponding changes in loss in dry weights at above mentioned stages of vase life evaluation were also noted. Maximum vase life (10.33 days) was recorded with gamma dose 0.20 kGy with 0.60 kGy in two day's treatment. Vase life value for control was 8.33 days. Reduction in vase life was observed with increase in storage duration. Significant variations in vase life up to five, four, and three day's treatments were observed with gamma doses 0.20, 0.40, and 0.60 kGy, respectively. Hence, it is concluded that gamma irradiation dose of 0.20 kGy is found best for increasing vase life.

Table 4.2.17 **Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on flower quality of cut rose cv. Noblesse (vase lives are given in Table 36)**

Storage days	Flower diameter (cm)											
	At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
2	1.58	1.59	1.60	3.02	2.99	2.96	5.07	5.03	4.96	7.91	7.82	7.76
3	1.60	1.60	1.65	3.15	3.12	3.05	4.98	4.92	4.88	7.81	7.70	7.68
4	1.57	1.63	1.63	3.28	3.21	3.15	4.80	4.74	4.75	7.71	7.57	7.52
5	1.61	1.58	1.57	3.40	3.34	3.28	4.72	4.66	4.63	7.55	7.48	7.44
6	1.62	1.62	1.56	3.55	3.49	3.44	4.62	4.57	4.52	7.45	7.39	7.36
7	1.58	1.60	1.59	3.66	3.60	3.55	4.56	4.51	4.37	7.36	7.32	7.15
8	1.62	1.57	1.58	3.75	3.68	3.61	4.42	4.36	4.20	7.12	7.06	6.88
9	1.61	1.58	1.60	3.84	3.79	3.70	4.29	4.24	4.12	6.93	6.85	6.74
10	1.58	1.63	1.59	3.90	3.86	3.78	4.15	4.11	4.05	6.82	6.74	6.65
Control	1.60	1.60	1.60	-	-	-	4.28	4.28	4.28	6.89	6.89	6.89
SEm±	0.020	0.024	0.026	0.063	0.054	0.052	0.076	0.056	0.069	0.138	0.120	0.117
F test	NS	NS	NS	**	**	**	**	**	**	**	**	**
CD at 5%	-	-	-	0.185	0.161	0.154	0.223	0.165	0.202	0.406	0.355	0.351

NS = Non significant
** = Highly significant

4.2.17 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on flower quality of cut rose cv. Noblesse

Flower diameter after cold storage, on 3rd day in vase, and on complete opening varied significantly with gamma rays 0.025, 0.05 and 0.10 kGy over control (Table 4.2.17 and Appendix 38). At harvest, variations in flower diameter were non-significant. During cold storage, maximum increase in flower diameter was recorded with gamma rays 0.025 kGy. With all the three doses, increase in flower diameter was noted with increase in storage duration. After cold storage, maximum flower diameter (3.90 cm) was recorded with 0.025 kGy in 10 day's treatment whereas the minimum (2.96 cm) with 0.10 kGy in two day's treatment. On 3rd day in vase, gamma rays dose 0.025 kGy was found better than 0.05 and 0.10 kGy. Maximum flower diameter (5.07 cm) was recorded with gamma rays dose 0.025 kGy in two day's treatment. Flower diameter on 3rd day in vase for control was 4.28 cm. Significant variations in flower diameter on 3rd day in vase were recorded up to seven day's treatments with gamma doses 0.025 and 0.05 kGy and up to six day's treatments with 0.10 kGy. On complete flower opening, decrease in flower diameter was recorded with increase in storage duration. Flower diameter on complete expansion for control was 6.89 cm. On complete flower opening maximum flower diameter (7.91 cm) was recorded with 0.025 kGy in two day's treatment and the minimum (6.65 cm) with 0.10 kGy in 10 day's treatment. Significant variations in flower diameter on complete expansion were recorded up to seven day's treatments with gamma doses 0.025 and 0.05 kGy and up to six day's treatments with 0.10 kGy.

4.2.18 Effect of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on flower quality of cut rose cv. Noblesse

It can be seen from Table 4.2.18 and Appendix 39 that flower diameter after cold storage, on 3rd day in vase, and on complete expansion varied significantly with gamma doses of 0.20, 0.40, and 0.60 kGy over control. Non-significant variations in flower diameter were noted at harvest. During cold storage, increase in flower diameter was recorded with increase in storage duration. Gamma dose 0.20 kGy was found better than 0.40 and 0.60 kGy. After cold storage, maximum flower diameter (3.69 cm) was recorded with 0.20 kGy in 10 days treatment whereas the minimum

Table 4.2.19 Effect of gamma irradiations (0.025 and 0.05 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^{0}C) on water uptake of cv. Noblesse (vase lives are given in Table 36)

Storage days	Water uptake (ml) in days after keeping cut flowers in vase (water)																							
	1		2		3		4		5		6		7		8		9		10		11		12	
	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05
2	3.00	2.93	7.23	7.19	12.55	12.47	15.93	15.85	19.52	19.45	22.80	22.72	25.65	25.58	28.21	28.15	30.49	30.42	32.00	31.90	32.85	32.72	33.28	33.09
3	2.88	2.76	7.25	7.11	12.19	12.13	15.45	15.37	19.18	19.10	22.21	22.15	25.16	25.12	27.72	27.65	29.92	29.85	31.25	31.16	32.53	32.40	33.03	32.75
4	2.78	2.72	7.00	6.95	11.50	11.82	14.82	14.70	18.09	18.04	21.65	21.59	24.35	24.30	27.29	27.19	29.00	28.92	30.88	29.35	31.45		31.82	
5	2.65	2.60	6.87	6.79	11.45	11.49	14.35	14.29	17.88	17.79	20.01	19.96	22.85	22.78	25.80	25.72	28.07	27.50	29.51	27.92	29.93			
6	2.52	2.49	6.75	6.63	10.90	10.57	13.82	13.72	17.55	17.40	19.57	19.42	22.53	22.40	24.55	24.35	24.88	24.72	25.30					
7	2.42	2.44	6.57	6.49	10.25	10.10	13.65	13.50	17.30	17.26	19.35	19.31	22.29	22.26	23.96	23.90	24.36	24.30						
8	2.18	2.13	6.10	6.00	8.76	8.69	12.43	12.36	14.83	14.70	16.50	17.42	17.08	18.13	17.40									
9	1.96	1.93	5.80	5.71	8.05	7.96	12.14	12.07	14.35	14.26	14.95	14.68												
10	1.75	1.71	4.09	3.99	6.62	6.53	7.25	7.19	7.96	7.89	8.41	8.22												
Control	2.28	2.28	6.25	6.25	9.70	9.70	12.93	12.93	15.99	15.99	18.60	18.60	21.22	21.22	22.88	22.88	23.15	23.15						
SEm±	0.037	0.045	0.101	0.079	0.159	0.127	0.216	0.166	0.270	0.268	0.233	0.233	0.309	0.309	0.273	0.264	0.279	0.234	0.260	0.235	0.315		0.221	
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**		**	
CD at 5%	0.111	0.133	0.299	0.232	0.469	0.376	0.637	0.488	0.796	0.791	0.687	0.687	0.911	0.911	0.805	0.778	0.824	0.692	0.766	0.694	0.931		0.653	

** = Highly significant

Table 4.2.20 Effect of gamma irradiations (0.10 and 0.20 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on water uptake of cut rose cv. Noblesse (vase lives are given in Tables 36 and 37)

Storage days	Water uptake (ml) in days after keeping cut flowers in vase (water)																							
	1		2		3		4		5		6		7		8		9		10		11		12	
	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20
2	2.89	2.79	7.12	7.05	12.40	12.33	15.70	15.64	19.36	19.30	22.60	22.54	25.49	25.38	28.06	27.94	30.34	29.15	31.75	30.02	32.50	30.46	32.94	
3	2.70	2.63	7.03	6.92	12.01	11.95	15.25	15.16	18.92	18.80	22.07	21.82	24.93	24.70	27.60	27.42	29.76	28.35	31.08	28.91	31.42			
4	2.62	2.54	6.88	6.73	11.72	11.40	14.60	14.47	17.95	17.88	21.45	21.30	24.21	24.09	27.07	26.60	28.78	27.22	29.15	27.53				
5	2.49	2.45	6.72	6.62	11.25	10.45	14.07	13.82	17.48	16.90	19.66	19.45	22.55	22.25	25.41	24.15	26.08	24.46						
6	2.40	2.34	6.60	6.48	10.42	10.04	13.59	13.35	17.25	16.48	19.36	17.90	22.29	18.29	23.80	18.62	24.25							
7	2.31	2.25	6.41	6.34	10.05	9.95	13.42	13.14	16.09	15.93	19.12	17.45	21.03	17.95	22.72		23.04							
8	2.09	2.00	5.94	5.82	8.61	8.23	12.28	11.07	14.62	12.50	17.35	13.48	17.86											
9	1.88	1.75	5.60	5.51	7.89	7.80	11.95	10.12	12.83	11.22	13.30	11.50												
10	1.65	1.56	3.91	3.71	6.25	5.95	7.08	6.70	8.90	7.31	9.25													
Control	2.28	2.28	6.25	6.25	9.70	9.70	12.93	12.93	15.99	15.99	18.60	18.60	21.22	21.22	22.82	22.88	23.15	23.15						
SEm±	0.029	0.035	0.066	0.093	0.126	0.128	0.165	0.211	0.202	0.237	0.231	0.218	0.307	0.284	0.222	0.322	0.341	0.310	0.283	0.207				
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**				
CD at 5%	0.086	0.102	0.195	0.275	0.372	0.377	0.486	0.624	0.595	0.698	0.681	0.642	0.906	0.839	0.655	0.949	1.006	0.915	0.834	0.61				

** = Highly significant

(2.81 cm) with 0.60 kGy in two day's treatment. On 3rd day in vase decrease in flower diameter with all the three doses was noted with increase in storage duration. On 3rd day in vase, maximum flower diameter (4.90 cm) was recorded with 0.20 kGy in two day's treatment whereas the minimum (3.82 cm) with 0.60 kGy in 10 day's treatment. Flower diameter on 3rd day in vase for control was 4.28 cm. On 3rd day in vase, flower diameter varied significantly up to five, four, and three day's treatments with gamma doses of 0.20, 0.40, and 0.60 kGy, respectively. On complete flower opening, reduction in flower diameter was noted with increase in storage duration. Gamma dose 0.20 kGy recorded maximum flower expansion followed by 0.40 and 0.60 kGy. On complete flower opening, maximum flower diameter (7.68 cm) was recorded with 0.20 kGy in two day's treatment whereas the minimum (6.07 cm) with 0.60 kGy in 10 day's treatment. Flower diameter on complete expansion for control was 6.89 cm. Flower diameter on complete expansion varied significantly up to five, four, and three day's treatments with gamma doses of 0.20, 0.40, and 0.60 kGy, respectively.

4.2.19 Effect of gamma irradiations (0.025 and 0.05 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on water uptake of cut rose cv. Noblesse

Perusal of Table 4.2.19 and Appendix 40 indicates that water uptake at 24 h intervals varied significantly with gamma doses 0.025 and 0.05 kGy over control. Decline in water uptake was observed with increase in storage duration. Initial rates of water uptake were higher than later ones. Highest total water uptake (33.28 ml) was recorded with ^{60}Co dose 0.025 kGy in two day's treatment whereas the minimum (8.41 ml) with 0.05 kGy in 10 day's treatment. Total water uptake for control was 23.15 ml. Significant variations in water uptake at different days were recorded up to seven days with gamma irradiation doses of 0.025 and 0.05 kGy. Hence, it is concluded that increased water uptake enhanced vase life and quality of cut flowers.

4.2.20 Effect of gamma irradiations (0.20 and 0.40 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on water uptake of cut rose cv. Noblesse

Water uptake at 24 h intervals varied significantly with ^{60}Co gamma doses 0.10 and 0.20 kGy over control (Table 4.2.20 and Appendix 41). Highest total water uptake (32.94 ml) was recorded with gamma irradiation 0.10 kGy in two day's treatment whereas the minimum (7.31 ml) with 0.20 kGy in 10 day's treatment. As

Table 4.2.21 **Effect of gamma irradiations (0.40 and 0.60 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on water uptake of cut rose cv. Noblesse (vase lives are given in Table 37)**

Storage days	Water uptake (ml) in days after keeping cut flowers in vase (water)																	
	1		2		3		4		5		6		7		8		9	
	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60
2	2.72	2.65	6.95	6.90	12.12	12.08	15.42	15.21	19.15	18.91	22.32	21.15	25.20	24.05	27.41	26.12	28.33	27.20
3	2.53	2.47	6.78	6.65	11.53	11.50	14.25	13.90	17.92	17.20	21.09	19.92	24.20	22.21	26.30	23.95	26.83	24.30
4	2.46	2.38	6.68	6.50	10.85	10.12	13.60	12.13	16.72	16.35	19.60	18.70	22.28	19.32	23.93	19.76	24.45	
5	2.34	2.33	6.43	6.40	10.00	9.81	13.30	11.37	16.48	14.39	19.22	15.82	22.07	16.50	22.52	16.96		
6	2.27	2.24	6.22	6.07	9.94	9.42	12.99	11.05	16.25	13.42	17.62	14.73	18.15	15.18				
7	2.18	2.18	6.29	5.90	9.82	8.73	12.15	10.69	15.80	11.87	16.72	12.60	17.12	12.92				
8	1.95	1.92	5.52	5.12	7.86	8.15	10.82	10.11	12.25	11.20	12.75	12.08		12.45				
9	1.62	1.69	5.08	5.35	7.42	7.65	9.73	8.82	10.82	9.25	11.26							
10	1.40	1.40	3.56	3.57	5.78	5.75	6.46	6.40	6.95	6.86								
Control	2.28	2.28	6.25	6.25	9.70	9.70	12.93	12.93	15.99	15.93	18.60	18.60	21.22	21.22	22.88	22.88	23.15	23.15
SEm±	0.027	0.041	0.075	0.089	0.120	0.163	0.154	0.174	0.189	0.173	0.319	0.226	0.337	0.204	0.216	0.267	0.201	0.169
F test	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**
CD at 5%	0.081	0.121	0.221	0.264	0.355	0.480	0.454	0.515	0.557	0.512	0.941	0.666	0.995	0.601	0.636	0.786	0.594	0.498

** = Highly significant

Table 4.3.1 Effect of gamma irradiation dose (0.25 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on changes in respiration rate of cut rose cv. Golden Gate

Storage days	Respiration rate (cc CO_2/g DW/h)					Vase life (days)
	At harvest	After irradiation	After cold storage	On 3rd day in vase	On senescence day in vase	
2	324.60	346.20	280.80	428.10	237.70	13.00
3	326.00	348.50	282.00	434.70	245.60	12.33
4	325.30	350.90	284.40	443.90	260.90	11.33
5	327.90	351.10	287.70	454.60	273.70	10.66
6	324.10	347.50	292.60	469.70	286.30	9.33
7	326.70	346.00	298.70	480.90	295.00	8.00
8	328.70	353.60	306.80	488.00	303.50	7.33
9	326.60	350.90	311.30	499.30	314.60	6.33
10	325.00	348.80	318.40	507.00	321.20	5.66
Control	327.80	-	-	485.00	290.10	8.00
SEm±	4.170	4.480	3.226	7.426	3.200	0.145
F test	NS	NS	**	**	**	**
CD at 5%	-	-	9.417	21.675	9.339	0.422

NS = Non significant
** = Highly significant

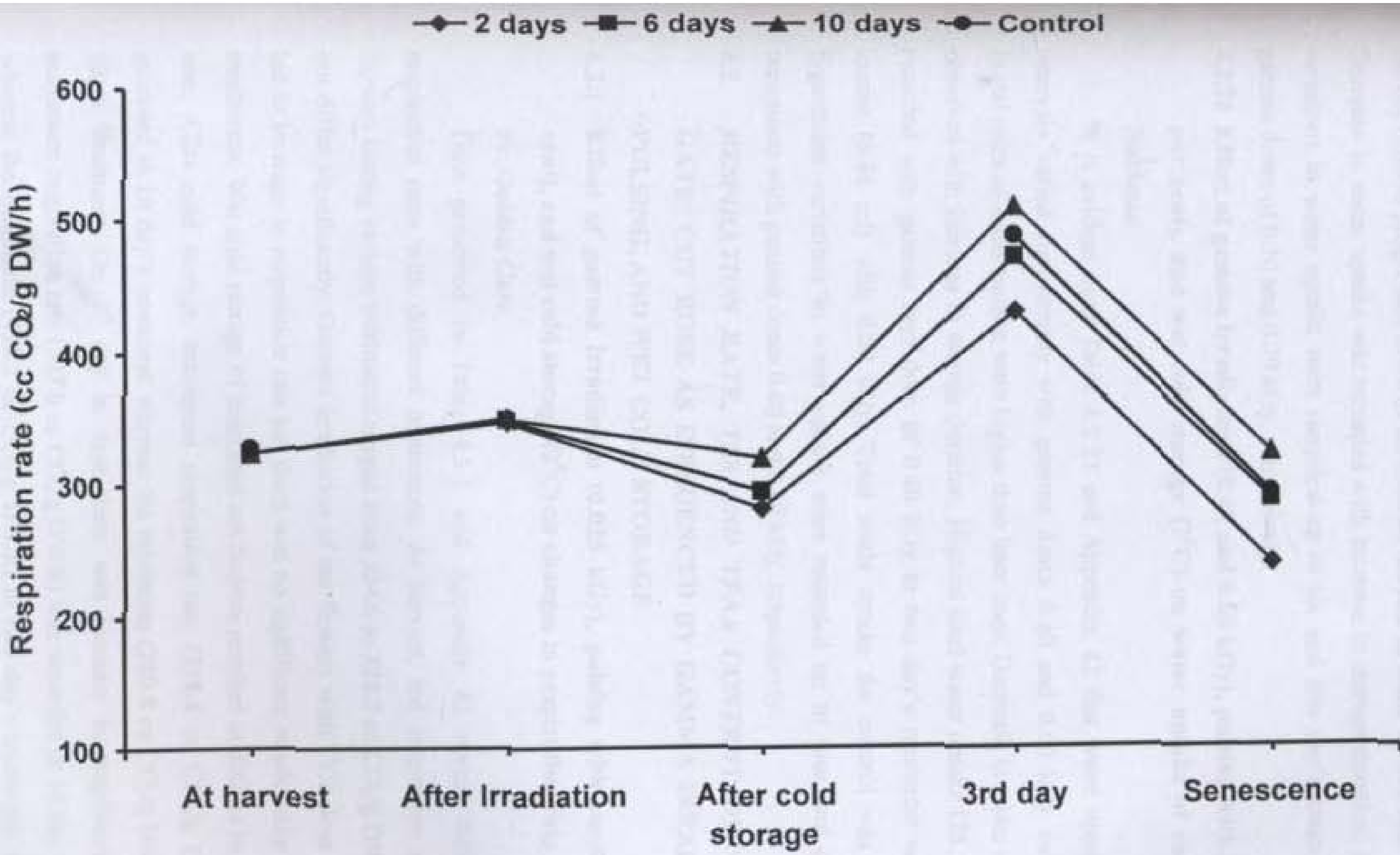

Fig. 3. Effect of gamma irradiation (0.025 kGy), pulsing with sucrose (3 %) and wet cold storage (2^0C) on changes in respiration rate of cut rose cv. Golden Gate

the cut flowers progressed towards senescence decline in water uptake rate was noted. Decrease in water uptake was recorded with increase in storage duration. Significant variations in water uptake were recorded up to six and five day's treatments with gamma doses of 0.10 and 0.20 kGy, respectively.

4.2.21 Effect of gamma irradiations (0.40 and 0.60 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on water uptake of cut rose cv. Noblesse

It is evident from Table 4.2.21 and Appendix 42 that water uptake at 24 h intervals varied significantly with gamma doses 0.40 and 0.60 kGy over control. Initial rates of water uptake were higher than later ones. Decrease in water uptake was observed with increase in storage duration. Highest total water uptake (28.33 ml) was recorded with gamma rays dose of 0.40 kGy in two day's treatment whereas the lowest (6.86 ml) with 0.60 kGy. Total water uptake for control was 23.15 ml. Significant variations in water uptake were recorded up to four and three day's treatments with gamma doses 0.40 and 0.60 kGy, respectively.

4.3 RESPIRATION RATE, TSS AND TFAA CONTENT OF 'GOLDEN GATE' CUT ROSE AS INFLUENCED BY GAMMA IRRADIATION, PULSING, AND WET COLD STORAGE

4.3.1 Effect of gamma irradiation (0.025 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on changes in respiration rate of cut rose cv. Golden Gate

Data presented in Table 4.3.1 and Appendix 43 reveal differences in respiration rates with different treatments. At harvest, the respiration rate of cut flowers among various treatments ranged from 324.6 to 328.7 cc CO_2/g DW/h and did not differ significantly. Gamma irradiation of cut flowers with ^{60}Co dose 0.025 kGy led to increase in respiration rate but there was no significant relationship among the treatments. Wet cold storage of irradiated cut flowers resulted in decline in respiration rate. After cold storage, maximum respiration rate (318.4 cc CO_2/g DW/h) was recorded in 10 day's treatment whereas the minimum (280.8 cc CO_2/g DW/h) in two day's treatment. On 3rd day in vase there was increase in respiration rate and maximum respiration rate (507.0 cc CO_2/g DW/h) was recorded in 10 day's treatment whereas the minimum (428.1 cc CO_2/g DW/h) in two day's treatment. Respiration rate declined on senescence day and the minimum was 237.7 cc CO_2/g DW/h in two

Table 4.3.2 Effect of gamma irradiation dose (0.025 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on changes in total soluble sugars content of cut rose cv. Golden Gate

Storage days	Total soluble sugars (TSS) (mg/g)					Vase life (days)
	At harvest	After irradiation	After cold storage	On 3rd day in vase	On senescence day in vase	
2	326.50	358.20	437.90	417.50	380.60	13.00
3	324.00	355.40	434.00	415.20	376.20	12.33
4	325.10	357.80	423.50	409.50	365.00	11.33
5	328.90	359.10	415.80	400.70	357.80	10.66
6	329.70	358.50	403.60	390.10	342.50	9.33
7	324.00	355.70	389.10	378.40	335.40	8.00
8	325.60	354.60	375.40	367.20	223.00	7.33
9	327.10	357.20	362.20	350.60	316.30	6.33
10	329.30	356.00	348.40	337.10	307.50	5.66
Control	325.20	-	-	309.00	282.00	8.00
SEm±	4.948	4.407	5.077	4.772	5.447	0.145
F test	NS	NS	**	**	**	**
CD at 5%	-	-	14.820	13.784	15.905	0.422

NS = Non significant
** = Highly significant

Table 4.3.3 Effect of gamma irradiation dose (0.025 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on changes in total free amino acid content of cut rose cv. Golden Gate

Storage days	Total free amino acid contents (mg/g)					Vase life (days)
	At harvest	After irradiation	After cold storage	On 3rd day in vase	On senescence day in vase	
2	57.61	60.75	60.13	64.23	77.31	13.00
3	53.18	57.45	63.25	66.67	80.23	12.33
4	55.25	56.37	66.57	71.92	83.54	11.33
5	57.38	59.46	71.65	75.37	89.62	10.66
6	57.56	61.11	77.82	82.15	93.75	9.33
7	54.09	58.66	81.21	88.26	98.77	8.00
8	53.73	55.81	87.38	94.02	104.80	7.33
9	57.52	57.73	93.17	102.60	112.30	6.33
10	58.62	60.85	99.27	108.70	117.50	5.66
Control	55.13	-	-	83.80	102.10	8.00
SEm±	0.703	0.709	0.975	1.310	1.197	0.145
F test	NS	NS	**	**	**	**
CD at 5%	-	-	2.845	3.824	3.493	0.422

NS = Non significant
** = Highly significant

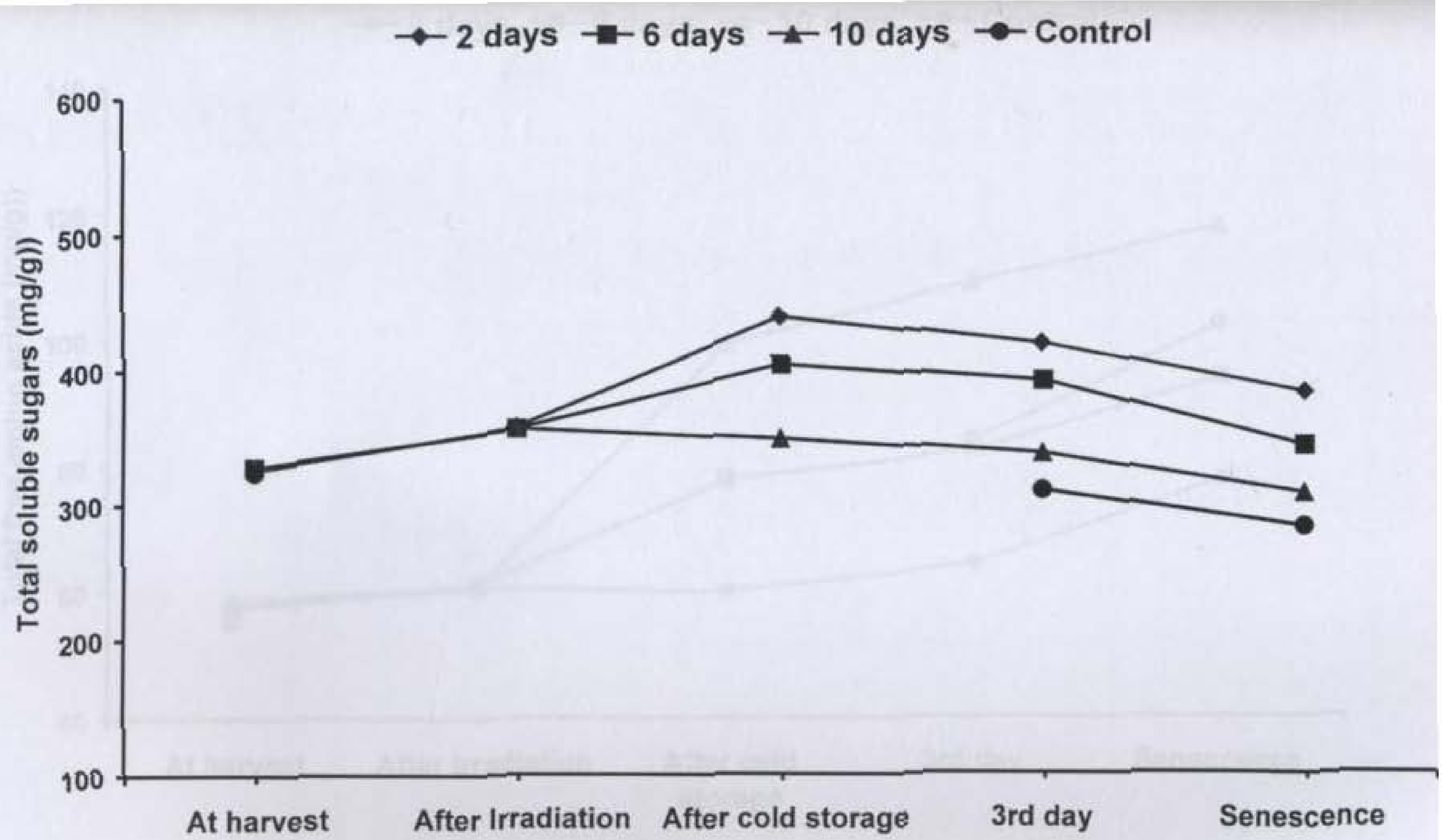

Fig. 4. Effect of gamma irradiation (0.025 kGy), pulsing with sucrose (3 %) and wet cold storage (2^0C) on changes in total soluble sugars of cut rose cv. Golden Gate

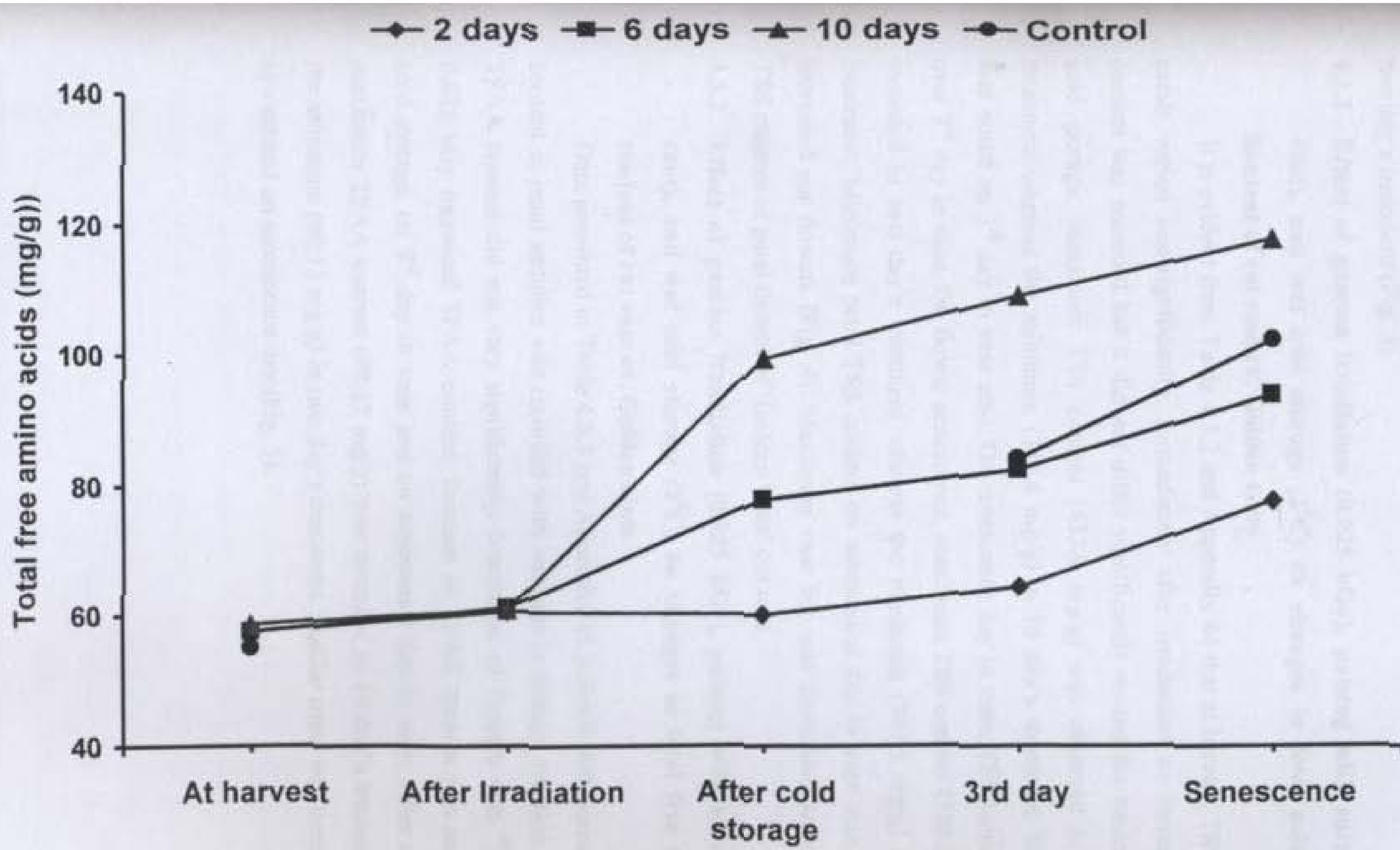

Fig. 5. Effect of gamma irradiation (0.025 kGy), pulsing with sucrose (3 %) and wet cold storage (2^0C) on changes in total free amino acids of cut rose cv. Golden Gate

day's treatment. Minimal respiration rate resulted in highest vase life (13.00 days) in two day's treatment (Fig. 3).

4.3.2 Effect of gamma irradiation (0.025 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on changes in total soluble sugars content of cut rose cv. Golden Gate

It is evident from Table 4.3.2 and Appendix 44 that at harvest, TSS content of petals varied non-significantly. Immediately after irradiation an increase in TSS content was recorded but it did not differ significantly among the treatments. After cold storage, maximum TSS content (437.9 mg/g) was observed in two day's treatment whereas the minimum (348.4 mg/g) in 10 day's treatment. Similar trend was noted on 3rd day in vase also. On senescence day in vase, TSS content declined over 3rd day in vase. On flower senescence, maximum TSS content (380.6 mg/g) was recorded in two day's treatment whereas the minimum (307.5 mg/g) in 10 day's treatment. Minimum petal TSS content on senescence day in vase was recorded in untreated cut flowers (Fig. 4). Maximum vase life was associated with increase in TSS content of petal tissues of 'Golden Gate' cut rose.

4.3.3 Effect of gamma irradiation (0.025 kGy), pulsing with sucrose (3 per cent), and wet cold storage (2^0C) on changes in total free amino acid content of cut rose cv. Golden Gate

Data presented in Table 4.3.3 and Appendix 45 indicate that increase in TFAA content in petal samples was recorded with increase in storage duration. At harvest, TFAA content did not vary significantly. Irradiation of flowers with ^{60}Co dose of 0.025 kGy increased TFAA content. Increase in TFAA content was recorded after cold storage, on 3rd day in vase and on senescence day in vase. After cold storage maximum TFAA content (99.27 mg/g) was recorded in 10 day's treatment whereas the minimum (60.13 mg/g) in two day's treatment. Similar trend was noted on 3rd day in vase and on senescence day (Fig. 5).

5. DISCUSSION

The previous studies revealed that pulsing of cut roses with sucrose (3 per cent) for 24 h increased vase life over other chemicals. Hence, in the present investigation, an attempt was made to study the effect of different doses of ^{60}Co gamma rays in conjunction with pulsing, and cold storage for different durations. The greenhouse grown cut flowers of 'Golden Gate', Mercedes', and 'Noblesse' cut roses were subjected to gamma irradiation doses viz., 0.025, 0.05, 0.10, 0.20, 0.40, and 0.60 kGy. Immediately after irradiation, the cut flowers were pulsed with sucrose (3 per cent) for 24 h, and then dry cold stored (2^0C) for 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 days, and wet cold stored (2^0C) for 2, 3, 4, 5, 6, 7, 8, 9, and 10 days. Vase life of cut roses was evaluated under ambient conditions. Respiration rate, total soluble sugars, and total free amino acid contents of flower petals were also studied in 'Golden Gate' cut flowers wet cold stored for different durations. The results obtained from various experiments are discussed hereunder.

5.1 CHANGES IN FRESH AND DRY WEIGHTS OF IRRADIATED AND PULSED CUT ROSES UNDER COLD STORAGE

In the present study it was found that fresh and dry weights of cut roses changed significantly over the fresh and dry weights at harvest. Increase in fresh and dry weights was recorded after cold storage, and on 3rd day in vase both under dry and wet cold storage. Decline in fresh and dry weights on senescence was noted under dry and wet cold storage. Maximum decline was recorded in control flowers. Sivasamy and Bhattacharjee (2000) also reported increase in fresh and dry weights of cold stored cut roses immediately after storage and decrease in the same at senescence. Reduction in fresh and dry weights increased with increase in storage duration. Increase in fresh weight of carnation flowers during the first six days of vase life was much higher when subjected to pulse treatment of sucrose (10 per cent) + thiabendazole glycolate (3 per cent) for 24 h than control flowers (Apelbaum and Katchansky, 1997). Increase in fresh and dry weight was due to higher water uptake and continuous development of flowers. This in turn increased petal weight and opening of flowers. This increase in fresh and dry weights was more pronounced in cut flowers which were wet cold stored. In wet cold storage basal end of flowers was kept in tap water that resulted in higher water uptake and continuous flower development thereby enhancing the ultimate life in vase and flower quality. Increased vase life with use of tap water over single and double distilled water has also been reported by Rajan and Bhattacharjee (1995). Van Meeteren *et al.* (2000) also reported sharp decline in fresh weight of cut chrysanthemum flowers held in deionized water.

Higher water uptake under wet cold storage might have resulted in better translocation of sucrose and its utilization and thereby prolonging the vase life and flower quality. Prevention of vascular occlusion in wet cold storage is well documented. Moreover, in wet cold storage increase in biological activities than dry cold storage is well established. In carnation flowers 20 per cent increase in fresh weight was observed by Goszezynska *et al.* (1982). Wet cold storage of rose might have resulted in higher respiration rate than dry cold stored cut flowers and thus better utilization of exogenous carbohydrates. This has also been reported in carnation flowers (Hardenburg *et al.*, 1969). Depletion of carbohydrates by respiration was more rapid in flowers stored in water than dry ones (Lutz and Hardenburg, 1968). Sucrose pulsing might have compensated depletion of endogenous carbohydrates during wet cold storage. Nichols (1969) also reported similar findings. Moreover, an improved water balance was observed in carnation flowers following preservative treatment during storage (Goszezynska *et al.*, 1982). In the present study also higher water uptake by rose flowers was recorded in wet cold storage than dry cold storage. Pre-market storage of roses in water at a temperature of 0^0 to 10^0C gave better results than dry cold storage period (De Boer and Witmondt, 1975). In all the three cultivars under investigation, increase in storage duration resulted in decreased vase life. Similar results have been obtained in 'Baccara' and 'Sonia' cut roses by Amariutei and Burzo (1982).

Water is quantitatively most abundant substance transported in the phloem. Solutes mostly carbohydrates are dissolved in water. Under wet cold storage translocation of sucrose is faster, which increased the carbohydrate substrate of actively metabolizing petal and leaf tissues and thus increased vase life and flower diameter with increase in water uptake. When rose flower shoots were cut and placed in water, symptoms of natural senescence was often not observed but symptoms of water stress such as premature wilting of the flowers and leaves were expressed (Van Doorn, 1997). For cell expansion water must enter the cell. Petal growth in cut roses is related to decline in starch content and a concomitant increase in reducing sugars (Evans and Reid, 1986, 1988; Van Doorn *et al*., 1991). Thus under wet cold storage higher flower diameter was recorded than dry cold storage. Adverse water relations during flower opening may inhibit petal growth. Petals of cut roses, which were stored, did not reach the same size as those of unstored controls. Even after prolonged dry storage the petals did not grow at all (Halevy and Mayak, 1975).

Initial rates of water uptake of dry and wet cold stored cut flowers were higher. As the cut flowers progressed towards senescence the reduction in rate of water uptake was recorded. Total water uptake also declined with the increase in storage duration both under dry and wet cold storage. In *Bouvardia*, *Astilbe*, some *Dendranthema* cultivars, *Polianthes tuberosa*, *Anigozanthos*, *Chamelaucium*, *Banksia*, *Grevillea* and *Telopea,* reduction in water uptake was noted as the flowers progressed towards senescence (Mayak *et al*., 1974; Tija and Funnell, 1986; Faragher *et al*., 1984; Naidu and Reid 1989). Under dry cold storage (water stress conditions), the cut flowers might have increased solute content per cell i.e. osmotic adjustment, thereby prevented the drop in the various cellular compartments, including inorganic and organic ions, soluble carbohydrates, and amino acids (Turner and Jones, 1980; Hansen and Hitz, 1982; Morgan, 1984).

5.2 POSTHARVEST LIFE OF CUT ROSES AS AFFECTED BY GAMMA IRRADIATION

The fresh and dry weights of irradiated, pulsed, and cold stored cut flowers varied significantly with variation in irradiation dose. Maximum gain in fresh and dry weights was recorded in irradiated (0.025 kGy) cut roses, pulsed, and dry cold stored for three days and wet cold stored for two days. Among all the treatments, both under dry and wet cold storage, fresh weights of cut flowers declined at senescence. During senescence substantial amount of water is lost from flower parts and there is reduction in petal turgidity. The reduction in fresh weights at senescence might be due to loss of water. Sultan and Farooq (1996) in *Hemerocallis fulva* and Coorts (1973) in roses also reported similar findings. In 10 rose cultivars, similar trend was also observed by Sivasamy and Bhattacharjee (2000). Higher water uptake was recorded with lower gamma irradiation doses and highest being with 0.025 kGy. There was reduction in flower diameter with higher doses (Plate 8). Similar results were obtained in *Protea compacta* flowers (Haasbroek *et al.*, 1973). Increase in vase life might be due to killing of microorganisms, and insect pests and fungal pathogens. Munasiri *et al.* (1987) also reported elimination of microorganisms in black pepper, turmeric and red chilli pepper with 10 kGy. In ginger, with same dose similar results were obtained (Andrews *et al.* 1995). Disinfestation of two-spotted spider mite (*Tetranychus urticae*) with irradiation (0.30 kGy) was reported (Goodwin and Wellham, 1990). Sterilization of adults of orchid thrips (*Thrips palmi*) with gamma irradiation was reported by Bansidhi *et al.* (2004). In alstroemeria, stock, and carnation similar findings were also reported (Takano, 2004). Higher doses reduced flower and foliage lives in *Chamelaucium uncinatum, Banksia hookeriana,* and *Anigozanthos manglessii* (Seaton and Joyce, 1992), and in chrysanthemum cut flowers (Chiu, 1986). Increased vase life and quality reported in the present investigation might be due to breakdown of complex carbohydrates into simpler ones. Bond breakage in proteins and depolymerization of starch have been reported by Grunewald (1984); and senescence and ethylene production by Thomas (1988). In the present study full expansion of flower was found reduced with increase in irradiation dose. Similar findings were reported in 'Raktagandha' cut rose (De *et al.*, 1997). Improved postharvest life and quality of 'Raktagandha' and 'Royalty' cut roses were also reported by Bhattacharjee and Roy (1994) and Gladon *et al.* (1997), respectively. Pulsing with sucrose prevented deterioration of cellular constituents of irradiated flowers. Similar findings were reported by Nakahara *et al.* (1998); Hayashi and Todoriki, (1996); and Hamidah *et al.* (2006). In chrysanthemum cv. Nilima loose flowers irradiated with 0.10 kGy could be stored for four days at 4^0C without affecting their longevity (Vinod Kumar *et al.*, 2002).

5.3 INFLUENCE OF PULSING WITH SUCROSE ON POSTHARVEST LIFE AND QUALITY OF CUT ROSES

In the present study, a series of experiments were conducted with different doses of gamma rays, and pulsing with sucrose (3 per cent), and cold storage. Pulsing with sucrose markedly improved vase life, flower quality and water uptake over the untreated cut flowers. Many researchers have reported increased flower diameter and quality with sucrose treatment. Sucrose might have delayed autocatalytic rise in ethylene production and the concomitant petal wilting. Exogenous sucrose might have replaced the depleted endogenous carbohydrates utilized during and after storage. Pulsing with sucrose provided continuation of normal metabolic activity after storage, and retardation of the process associated with senescence. High sugar levels decreased the transcription rate and expression of genes for many photosynthetic enzymes (Koch, 1996). Exogenous sucrose delayed degradation of proteins and ribonucleic acids, and maintained membrane integrity and mitochondrial structure and function. Similar findings were reported by Halevy and Mayak (1979) and decreasing sensitivity to exogenous ethylene (Mayak and Dilley, 1976; Mayak and Kofranek, 1976) is well established. Sucrose might have improved petal water balance by stimulation of stomatal closure (Marousky, 1969). Moreover, accumulation of applied sugars in petal cells increased solute concentration and improved ability of cells to absorb water and maintain turgidity (Acock and Nichols, 1979). Petal water content in 'Mercedes' cut rose increased with sucrose treatment (Oren *et al.*, 2001). In the present investigation also sucrose pulsing has resulted in increased post-storage life of cut roses. Pulsing treatment decreased the transcription rate in roses because of its role in stomatal closure (Marousky, 1969, 1972; Venkatarayappa *et al.*, 1981). High concentration in petal cells might have delayed loss of turgor when water deficit develops. Holding cut dahlia (Aarts, 1957b) and carnation flowers (Acock and Nichols, 1979) in sucrose solution delayed wilting and in gladioli long vase life was reported with sucrose pulse treatment (Halevy and Mayak, 1974). Treatment with sucrose not only extended the vase life but also promoted the flower opening. In addition, sucrose improved the petal colour expression. Wet cold stored cut roses exhibited higher flower diameter than dry cold stored ones. This might have been due to reduction in petal water potential by sucrose pulsing and thus continuous holding of cut flowers in tap water resulted in greater water influx. This in turns increased cell enlargement, which ultimately resulted in increased flower opening. Ho and Nichols (1977) also reported similar findings. Respiration continued after flower was harvested but little photosynthesis occurred because of light limitation in cold storage. So sucrose pulsing might have compensated this loss of carbohydrates through respiration. Thimann *et al.* (1977) hypothesized that sugar starvation is the direct cause of leaf senescence. In 'Raktagandha' cut rose pulsing with sucrose (3 per cent) for 24 hour increased water uptake, gained fresh weight at senescence and improved flower quality (Singh, 1995). Lee and Xue (2001) suggested that sucrose increased water content and decreased degradability of soluble protein in cut rose cv. Samantha flowers. Hence senescence duration decreased and peduncle water potential increased with increase in sucrose concentration in 'First Red' cut rose (Bhaskar *et al.*, 2002). Bhattacharjee and Palanikumar (2001) reported beneficial effects of sucrose pulsing in roses, Suman *et al.* (2002) in carnation, Mani and Pathania (2002) in gladiolus and Nagaraju *et al.* (2002) in tuberose.

5.4 INFLUENCE OF COLD STORAGE ON VASE LIFE AND QUALITY OF CUT ROSES

Decrease in vase life and flower quality was noted in all the three cultivars with increase in storage duration. The cut flowers were harvested when all the sepals were at right angle to the bud and one outer petal had started unfurling from the tip. Bhattacharjee (1992) also found this stage of harvest as stage for prolonged vase life of cut roses. At this stage lower respiration rate, sensitivity to ethylene and lower susceptibility of petals to fungal disease is well established. It was reported that bud cut carnation flowers lasted longer than other stages of harvest. Supremacy of bud cut carnation flowers can be attributed to lower respiration rate (Kuc and Workman, 1964), lower sensitivity to exogenous ethylene (Barden and Hansen, 1972), lower susceptibility of petals to fungal diseases, and reduced petal surface area and thus lower water loss. In the present study cut roses were stored dry and wet for different durations at constant temperature of 2^0C. Temperature range of 0^0 to 1^0C was recommended for the safe storage of rose cut flowers (Bredmose, 1980). Low temperature reduces respiration, transpiration, ethylene biosynthesis, microbial growth, and enzyme activities. Cold storage of cut roses might have reduced respiration and conserved carbohydrates, thereby prolonging flower quality and vase life. Sucrose pulsing might have reduced the chilling and freezing injuries to cut flowers. This is in line with the findings of Heins *et al.* (1981). They reported that freezing point of carnation was substantially reduced with high concentration of sucrose treatment. Cut roses placed in water at 2^0C rehydrated much more rapidly than those placed in water at 23^0C (Durkin, 1979). Cold storage of cut roses might have increased the capacity of petals to take up sucrose, increased activity of membrane ATPase, decreased membrane microviscosity and increased membrane phospholipids content. The changes have been reported in cold stored cut carnation flowers by Faragher *et al.* (1984). These changes resulting from low temperature storage were contrary to the changes occurring during normal senescence at ambient temperatures. The aforementioned changes which occurred in cells during cold storage could be the result of the adaptation of flowers to low temperatures. Storage of cut flowers at low temperature might have affected the cell properties, and slowed down the pace of flower senescence. At lower temperature storage of cut roses, ethylene action might have been prevented and thus there was absence of senescence symptoms. Cold storage might have delayed the rate of ion leakage from rose petals and thus would have maintained membrane integrity. This has also been reported in cut roses by Mayak and Faragher (1986).

During dry cold storage cut flowers were packed in polyethylene bags (80 gauge). Five holes of uniform size were made so as to allow the exchange of gases inside the bags with outside environment. Packaging of cut roses in polyethylene bags increased CO_2 concentration inside the bags that might have acted as inhibitor of ethylene biosynthesis. Use of perforated bags has also been recommended for storage of cut flowers (Hardenburg *et al.*, 1970). Cut rose 'Christian Dior' sealed in polyethylene bags and kept dry at 3 ± 1^0C gave a storage life of 12 days (Ketsa and Dadaung, 1989). Cut rose 'Gabriella' dry cold stored at 1^0C for three weeks was four days shorter than fresh ones (Mor *et al.*, 1989). In all the three cultivars, prolonged storage period reduced water uptake, flower diameter, and vase life. Similar findings were obtained by Palanikumar and Bhattacharjee (2001). Reduced neck bending and low respiration rate were observed in cold stored 'Golden Gate' cut rose. Pal *et al.* (2003) also observed similar findings in 'First Red' cut rose.

5.5 INFLUENCE OF GAMMA IRRADIATION, PULSING, AND WET COLD STORAGE ON RESPIRATION RATE OF 'GOLDEN GATE' CUT ROSE

Respiration rate at harvest and immediately after irradiation varied non-significantly among the respective treatments but respiration rate immediately after irradiation was higher than that at harvest. Increase in respiration rate after irradiation might be because of two reasons viz., effect of gamma rays on breakdown of complex macromolecules into simpler ones and supply of exogenous sugar through pulsing. Effect of irradiation on bond breakage in proteins and depolymerization of starch has been studied by Grunewald (1984). Sucrose might have been broken down into two monosaccharides i.e. glucose and fructose, which can readily enter the glycolytic pathway. Thus free energy might have been released and incorporated in the form of ATP that can be readily utilized for the maintenance and development of the flower. Marousky (1977) reported that sucrose increased respiratory rate of rose petals. In the present study during cold storage, respiration rate in 'Golden Gate' flowers declined. Decline in respiration with decreasing temperature is well documented. Lowest respiration rate was noted in cut flowers stored for two days whereas the highest in 10 days storage. Lower respiration rate at various stages of flower development is associated with increase in vase life and flower quality as have also been reported (Coorts, 1973; Bhattacharjee and Pal, 1999; Sivasamy, 1998; Singh *et al.*, 2001). Decrease in respiration rate in rose flowers cv. Visa stored at 4^0C was discussed by Serrano *et al.* (1992). Precooled 'Raktagandha' cut rose stored at 4^0C showed reduced respiration rate (Palanikumar *et al.* 2000). Linear relationship between respiration during storage and vase life after storage of cut rose 'First Red' and gypsophila 'Bristol Fairy' has been reported (Celikel and Reid, 2005). Respiration rate increased after bringing the cut flowers from cold store and thereafter declined at senescence. Increase in respiration rate on 3^{rd} day in vase might be due to sucrose pulsing. Exogenous sucrose helps in maintaining mitochondrial structure and functions, thereby extending the longevity of cut flowers (Kaltaler and Stephonkus, 1976). Respiration rate decreases as the plants mature and progresses towards senescence. Nichols (1973) emphasized that gradual reduction in respiration in ageing flowers may be due to decline in supply of respiratory substrate, mainly sugars.

5.6 EFFECT OF GAMMA IRRADIATION, PULSING, AND WET COLD STORAGE ON TOTAL SOLUBLE SUGARS CONTENT OF CUT ROSE 'GOLDEN GATE' PETALS

Total soluble sugar (TSS) content of 'Golden Gate' rose petals was non-significant at harvest and also immediately after irradiation among the respective treatments but TSS content was higher in irradiated flowers than non irradiated ones at harvest. This might be due to breakdown of complex carbohydrates into component parts. Reduction in total carbohydrates of oyster mushrooms when irradiated with 0.5 kGy has also been reported (Roy *et al.*, 2000). During cold storage, TSS content was highest in two day's storage and least in 10 day's storage. Storage of spathes of anthurium (*Anthurium andraeanum* Andre) at 4^0C tended to slow the loss of reducing sugars (Pritchard *et al.*, 1991). Ichimura *et al.* (1999) observed that concentration of glucose, fructose, and sucrose in the petals of 'Serena' roses was increased with sucrose and HQS treatment. Accumulation of reducing sugars was reported in petals of roses fed with sucrose (Paulin, 1980). Increase in vase life is positively correlated with TSS content of petal tissues (Eason *et al.*, 1998; Ichimura *et al.*, 1999; Kim and Lee, 2002b; Singh *et al.*, 2004; Shiva and Bhattacharjee, 2006). Decrease in TSS content with increase in storage duration was due to utilization of carbohydrates by the senescing flowers during storage though at reduced pace and this resulted in lowest vase life of 10 days stored flowers. Cut rose cv. Serena pretreated with sucrose (8 per cent) and 8-HQC (200 ppm), followed by 6 days in cold storage at 2^0C had 60 per cent more carbohydrates and this was due to hydrolysis of nutritional reserves under stress conditions (Garibaldi and Deambrogio, 1993).

5.7 EFFECT OF GAMMA IRRADIATION, PULSING, AND WET COLD STORAGE ON TOTAL FREE AMINO ACID CONTENT OF CUT ROSE 'GOLDEN GATE' PETALS

Changes in total free amino acid content of petal tissues at harvest and immediately after irradiation were found non-significant among respective treatments but TFAA was found higher immediately after irradiation treatment than at harvest. This increase in TFAA contents immediately after irradiation might be due to bond breakage in proteins. This has also been reported by Grunewald (1984). Increase in TFAA contents was found during cold storage but increase was more in 10 day's stored cut flowers. This might be due to stress conditions and senescing flowers though at slow pace. Lowest TFAA contents were found in two day's storage. This might be due to reduction of TFAA contents because of sucrose pulsing. Treatment of flowers with sugars as pulsing or holding solutions resulted in lowest accumulation of free amino acids as has been reported by others (Lukaszewska, 1980; Gao, 1991; Gao and Wu, 1990; De *et al*., 1996; Sivasamy, 1998; Bhattacharjee, 1999). An exogenous supply of sugars delays the onset of excessive protein degradation and also serves as substrate of protein synthesis (Parups and Chan, 1973; Paulin, 1977). TFAA contents on 3rd day in vase and on senescence day increased in the present study. Senescence process occurring in flowers might result in increase in TFAA content. Prolonged storage and increase in TFAA content might be duē to the proteolysis in the petal tissues. Amount of TFAA content in petal tissues is correlated with vase life. Increase in TFAA contents results in decreased vase life. Lowest TFAA contents in the present investigation were found in two day's wet cold stored flowers and highest in 10 day's storage and thus two-day's stored cut flowers exhibited highest vase life of 13.00 days.

6. SUMMARY AND CONCLUSIONS

In the present investigation, a series of experiments were conducted on three cut roses 'Golden Gate', 'Mercedes', and 'Noblesse' to evaluate the effect of different doses of ^{60}Co gamma rays in conjunction with dry and wet cold storage on vase life and intrinsic quality of flowers. The results obtained from various experiments are summarized hereunder.

Differences in vase life of cut roses with different doses 0.025, 0.05, 0.10, 0.20, 0.40, and 0.60 kGy were recorded. Maximum vase life in all the three cultivars was observed with ^{60}Co dose 0.025 kGy whereas the minimum with 0.60 kGy under both dry and wet cold storage. Reduction in vase life in all the three cultivars was noted with increase in storage duration from 3 to 12 days under dry and 2 to 10 days under wet cold storage.

Among the cultivars, Golden Gate was evaluated as best in respect to vase life and flower quality both under dry and wet cold storage (2^{0}C). Performance of cut roses under wet cold storage was better than dry cold storage in terms of extension in vase life and flower quality. With gamma rays 0.025 kGy and pulsing with sucrose (3 per cent) for 24 h, under two days wet cold storage maximum vase lives (13.00, 11.00, and 12.00 days) were recorded in 'Golden Gate', 'Mercedes', and 'Noblesse' cut roses, respectively. With the same irradiation dose and pulsing, under three days dry cold storage, maximum vase lives of 1200, 10.00, and 11.66 days were recorded in 'Golden Gate', Mercedes', and 'Noblesse' cut roses, respectively. With ^{60}Co dose of 0.025 kGy and pulsing with sucrose (3 per cent) for 24 h, cut flowers of Golden Gate', and 'Mercedes' cut roses can be dry cold stored (2^{0}C) for seven days and 'Noblesse' for six days without decline in vase life over untreated cut flowers. With the same irradiation dose and pulsing, cut flowers of 'Golden Gate', and 'Noblesse' cut roses can be wet cold stored (2^{0}C) for six days and 'Mercedes' for eight days without affecting ultimate life of flowers in vase water. With the increase in gamma irradiation dose as well as storage duration, the reduction in vase life was observed.

Differences in flower diameter of cut roses after cold storage, on 3rd day in vase, and on complete expansion recorded among the three cultivars. Variations in flower diameter were also noted on aforementioned stages with the variations in gamma irradiation doses and storage duration from 3 to 12 days under dry and 2 to 10 days under wet cold storage. Flower diameter in all the three cultivars was highest in three days treatment under dry and two days treatment under wet cold storage. Highest flower diameter on various stages was recorded with gamma rays dose 0.025 kGy in all the three cultivars both under dry and wet cold storage whereas the lowest with 0.60 kGy. With gamma irradiation dose of 0.025 kGy and pulsing with sucrose (3 per cent) for 24 h, highest flower diameters i.e. 8.02, 7.56, and 7.91 cm were recorded under two days wet cold storage in 'Golden Gate', 'Mercedes', and 'Noblesse' cut roses, respectively. With the same gamma rays dose and pulsing, highest flower diameters of 7.92, 7.45, and 7.91 cm were recorded under three days dry cold storage in 'Golden Gate', 'Mercedes', and 'Noblesse' cut roses, respectively. There was a significant improvement in flower diameters among all the three cultivars with gamma irradiation doses of 0.025, 0.05, 0.10, 0.20, 0.40, and 0.60 kGy.

Variations in water uptake at 24 h intervals were recorded among all the three cultivars with the variations in gamma rays dose and storage duration. Highest water uptake was recorded among all the cultivars with gamma rays dose 0.025 kGy in three days dry and two days wet cold storage. Reduction in water uptake was noted among the cultivars with the increase in storage duration. As the cut flowers progressed towards senescence decline in water uptake rates was observed. Higher water uptake was noted under wet cold storage than dry cold storage. With gamma rays dose 0.025 kGy and pulsing with sucrose (3 per cent) for 24 h, highest water uptakes i.e. 34.95, 31.80, and 33.28 ml were recorded in wet cold stored 'Golden Gate', 'Mercedes', and 'Noblesse' cut roses, respectively under two days treatment. With the same irradiation dose and pulsing treatment, highest water uptakes i.e. 33.80, 30.09, and 32.84 ml were recorded in dry cold stored 'Golden Gate', 'Mercedes', and 'Noblesse' cut roses, respectively under three days treatment.

Maximum gain in fresh and dry weights, after cold storage, on 3rd day in vase, and on senescence were recorded among all the three cultivars with irradiation dose 0.025 kGy under three days dry and two days wet cold storage. Minimum loss in fresh and dry weights was recorded with cut flowers exhibiting highest vase life and flower quality.

Respiration rate in 'Golden Gate' cut rose varied with wet cold storage duration. Non-significant variations in respiration rates were recorded at harvest and immediately after irradiation among respective treatments. Decline in respiration rate in irradiated (0.025 kGy) and pulsed cut flowers, during cold storage was noted. After cold storage, highest respiration rate of 318.4 cc CO_2/g DW/h was recorded in 10 day's treatment whereas the lowest (280.8 cc CO_2/g DW/h) in two day's treatment. On 3rd day in vase and on senescence day similar trend in respiration rate was observed. Peak in respiration rate was recorded on 3rd day in vase and thereafter decline in respiration rate was seen as flowers progressed towards senescence. Highest respiration rate was found in cut flowers that exhibited lowest vase life.

Total soluble sugars and total free amino acid contents of 'Golden Gate' cut rose petal samples varied at harvest, immediately after irradiation, after cold storage, on 3rd day in vase, and on senescence day. Immediately after irradiation, increase in TSS content of petals was recorded. After cold storage, highest TSS content of 737.9 mg/g was recorded in two days treatment whereas the lowest (348.4 mg/g) in 10 day's treatment. Highest TSS content was found in two day's wet cold stored flowers which have highest vase life. Immediately after irradiation, TFAA content of flowers increased. After cold storage, highest TFAA content i.e. 99.27 mg/g was recorded in 10 day's treatment whereas the lowest (60.13 mg/g) in two day's treatment. Highest TFAA content was recorded in 10 day's wet cold stored flowers which had lowest vase life.

Hence, from the present investigation it is concluded that gamma irradiation doses of 0.025, 0.05, 0.10, 0.20, 0.40, and 0.60 kGy and pulse treatment with sucrose (3 per cent) for 24 h enhanced vase life and flower expansion. But vase life and flower opening were more pronounced with irradiation dose 0.025 kGy.

CONCLUSIONS

- Gamma rays dose 0.025 kGy was found best for increasing vase life and flower quality in 'Golden Gate', 'Mercedes', and 'Noblesse' cut roses. Reduction in vase life and flower diameter was noted with increase in irradiation dose, being more pronounced with 0.60 kGy.
- Better results were obtained under wet cold storage (2^0C) than dry cold storage (2^0C) for extension in vase life.
- Highest flower diameter and water uptake was recorded among all the three cultivars treated with ^{60}Co gamma dose 0.025 kGy and dry cold stored for three days and wet cold stored for two days.
- Lowest respiration rate was found in 'Golden Gate' cut flowers wet cold stored (2^0C) for two days.
- Highest TSS and lowest TFAA content was found in cut flowers under two days wet cold storage (2^0C).

FUTURE LINE OF WORK

- Effect of gamma irradiation on ethylene biosynthesis and action may be studied in detail.
- Influence of gamma irradiation and in conjunction with pulsing and cold storage of other cut flower species and cultivars may be investigated.
- Influence of gamma irradiations and storage on physiological and biochemical changes may be studied in detail so that these changes may be manipulated for extension of post storage life of cut flowers.
- Gene expression induction by gamma rays should also be studied in detail among various cut flowers.

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ABSTRACT

In the present investigation, a series of experiments were conducted to evaluate the effect of ^{60}Co gamma rays in conjunction with dry and wet cold storage for enhancing vase life and intrinsic quality of cut roses. Cut flowers of 'Golden Gate', 'Mercedes', and 'Noblesse' were irradiated with gamma rays doses 0.025, 0.05, 0.10, 0.20, 0.40, and 0.60 kGy, and then pulsed with sucrose (3 per cent) for 24 h. Thereafter cut flowers were dry cold stored at 2^0C for 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 days, and wet cold stored at 2^0C for 2, 3, 4, 5, 6, 7, 8, 9, and 10 days. Vase life of cut roses was evaluated under ambient conditions.

It was found that in all the three cultivars with increase in gamma irradiation dose as well as storage duration, the vase life and quality of cut flowers reduced. Highest vase life and flower quality was recorded under three days dry and two days wet cold storage. Gain in fresh and dry weight, and water uptake was highest under three days dry, and two days wet cold storage. With irradiation dose of 0.025 kGy and pulse treatment with sucrose (3 per cent) for 24 h, highest vase lives i.e. 13.00, 11.00, and 12.00 days were recorded under two days wet cold storage in 'Golden Gate', 'Mercedes', and 'Noblesse' cut roses, respectively. With the same irradiation dose and pulse treatment highest vase lives of 12.00, 10.00, and 11.66 days were recorded under three days dry cold storage in 'Golden Gate', 'Mercedes', and 'Noblesse' cut roses, respectively. Cut flowers of 'Golden Gate', and 'Noblesse' can be wet cold stored for six days, and 'Mercedes' for eight days. Cut flowers of 'Golden Gate', and 'Mercedes' can be dry cold stored for seven days and 'Noblesse' for six days without any reduction in vase life and quality over untreated flowers.

Respiration rate studies were conducted on 'Golden Gate' cut rose treated with ^{60}Co dose 0.025 kGy and wet cold stored for 2, 3, 4, 5, 6, 7, 8, 9, and 10 days. Lowest respiration rate was recorded immediately after irradiation, after cold storage, on 3rd day in vase, and on senescence day in cut flowers stored for two days whereas the highest for 10 days. Cut flowers which recorded lowest respiration rate exhibited highest vase life. Differences in total soluble sugars and total free amino acids were recorded in 'Golden Gate' cut rose cold stored immediately after irradiation, on 3rd day in vase, and on senescence day. Highest TSS and lowest TFAA content were found in cut flowers stored for two days. Hence it was concluded that gamma irradiation dose of 0.025 kGy was found best in enhancing the vase life and quality of cut flowers in all the three cultivars.

सारांश

वर्तमान अनुसंधान के तहत काटे गए गुलाब का फूलदान–जीवन और आंतरिक गुणवत्ता बढ़ाने के लिए शुष्क एवं नमी–शीत भंडारण के साथ ^{60}Co गामा किरणों का प्रभाव जानने के लिए श्रृंखलाबद्ध अनुसंधान किए गए। 'गोल्डन गेट', 'मर्सिडीज' तथा 'नोबलेस' के कटे गुलाब गामा किरणों की 0.025, 0.05, 0.10, 0.20, 0.40 तथा 0.60 kGy मात्रा से उपचारित किये तथा फिर 24 घंटों के लिए चीनी (3 प्रतिशत) के साथ स्पंदित हुए। तदुपरांत कटे हुए फूलों को शुष्क शीत भंडार में 3,4,5,6,7,8,9,10,11 तथा 12 दिनों के लिए 2^0C तापमान पर रखा गया तथा नमी वाले शीत भंडारगृह में 2^0C तापमान पर 2,3,4,5,6,7,8,9 तथा 10 दिनों के लिए रखा गया। परिवेश परिस्थितियों के अंतर्गत कटे गुलाब के फूलदान–जीवन का मूल्यांकन किया गया।

उपरोक्त सभी तीनों गुलाब किस्मों में यह पाया गया कि गामा विकिरण मात्रा में बढ़ोतरी के साथ–साथ भंडारण अवधि में बढ़ोतरी करने से फूलदान जीवन और कटे फूलों की गुणवत्ता में कमी आयी। शुष्क– और नमी– वाले शीत भंडार में क्रमशः तीन दिन और दो दिन तक अधिकतम फूलदान जीवन और फूल गुणवत्ता दर्ज की गयी। शुष्क– और नमी– वाले शीत–भंडार में क्रमशः तीन और दो दिन तक ताजा तथा शुष्क भार और जल–ग्रहण क्षमता अधिकतम थी। 24 घंटों के लिए 0.025 kGy के विकिरण मात्रा और चीनी (3 प्रतिशत) के साथ स्पंदन उपचार से नमी वाले शीत भंडार में दो दिनों तक 'गोल्डन गेट', 'मर्सिडीज' तथा 'नोबलेस' के कटे गुलाबों के लिए क्रमशः 13:00, 11:00 तथा 12:00 दिनों का अधिकतम फूलदान–जीवन दर्ज किया गया। 'गोल्डन गेट' तथा 'नोबलेस' के कटे गुलाबों को 6 दिनों तक तथा 'मर्सिडीज' के कटे गुलाबों को आठ दिनों तक नमी वाले शीत भंडार में सुरक्षित रखा जा सकता है। फूलदान जीवन में तथा गैर–उपचारित फूलों की गुणवत्ता में बिना किसी गिरावट दर्ज किए शुष्क शीत–भंडार–गृहों में 'गोल्डन गेट' एवं 'मर्सिडीज' के कटे गुलाबों को 7 दिनों तक और 'नोबलेस' के कटे गुलाबों को 6 दिनों तक सुरक्षित रखा जा सकता है।

2,3,4,5,6,7,8,9 तथा 10 दिनों के लिए नमी वाले शीत–भंडार–गृहों में ^{60}Co की 0.025 kGy विकिरण मात्रा के साथ उपचारित 'गोल्डन गेट' के कटे गुलाबों पर श्वसन दर अध्ययन किए गए। विकिरण के तुरंत पश्चात् शीत भंडारण के बाद, फूलदान में तीसरे दिन न्यूनतम श्वसन–दर दर्ज की गई तथा दो दिनों के लिए भंडारित किए गए कटे फूलों में गुलदान पुष्प जीवनन दिन पर 10 दिनों के लिए श्वसन दर अधिकतम थी। न्यूनतम श्वसन–दर दर्ज कराने वाले कटे गुलाबों में अधिकतम फूलदान जीवन देखने में आया। विकिरण के तुरंत पश्चात् फूलदान में तीसरे दिन तथा गुलदान पुष्प जीवनन दिन पर 'गोल्डन गेट' के कटे गुलाब फूलों में शीत–भंडारण में कुल घुलनशील चीनी तथा कुल मुक्त अमीनो अम्ल में अंतर दर्ज किया गया। दो दिनों के लिए भंडारित किए गए कटे फूलों में अधिकतम कुल घुलनील ठोस तथा न्यूनतम कुल मुक्त अमीनो अम्ल मात्रा पायी गयी। अतः यह निष्कर्ष निकाला गया कि सभी तीन किस्मों के कटे गुलाब फूलों की गुणवत्ता और फूलदान–जीवन में वृद्धि के लिए 0.025 kGy की गामा विकिरण मात्रा सर्वश्रेष्ठ थी।

Appendix 1. Analysis of variance of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Golden Gate

Analysis of variance	d.f.	Changes in fresh weight (g)								
		After cold storage			On 3rd day in vase			On senescence day in vase		
		0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
Treatment	10	0.5010	0.4363	0.3606	0.2483	0.2147	0.1669	1.2328	1.1797	0.1699
Error	22	0.0007	0.0000	0.0006	0.0028	0.0014	0.0013	0.0018	0.0021	0.0034
Total	32	0.9657	0.9675	0.9675	0.9476	0.9598	0.9567	0.9657	0.9786	0.9576

Appendix contd.....

Appendix contd.....

Analysis of variance	d.f.	Changes in dry weight (g)									Vase life (days)		
		After cold storage			On 3rd day in vase			On senescence day in vase			0.025	0.05	0.10
		0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10			
Treatment	10	0.0217	0.0100	0.0164	0.0111	0.0090	0.0068	0.0339	0.0502	0.0486	16.6795	15.6117	6.4820
Error	22	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.1237	0.0586	0.1106
Total	32	0.9786	0.9675	0.9587	0.9675	0.9587	0.9547	0.9767	0.9675	0.9675	0.9657	0.9786	0.9657

Appendix 2. Analysis of variance of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Golden Gate

Analysis of variance	d.f.	Changes in fresh weight (g)								
		After cold storage			On 3rd day in vase			On senescence day in vase		
		0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
Treatment	10	0.1703	0.0698	0.0496	0.1276	0.0960	0.1263	1.1749	1.3145	1.3514
Error	22	0.0002	0.0000	0.0001	0.0007	0.0002	0.0003	0.0016	0.0025	0.0030
Total	32	0.9786	0.9768	0.9734	0.9677	0.9768	0.9587	0.9776	0.9670	0.9657

Appendix contd.....

Appendix contd.....

Analysis of variance	d.f.	Changes in dry weight (g)									Vase life (days)		
		After cold storage			On 3rd day in vase			On senescence day in vase			0.20	0.40	0.60
		0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60			
Treatment	10	0.0076	0.0033	0.0026	0.0058	0.0049	0.0059	0.0497	0.0569	0.0583	13.4105	12.6337	12.9563
Error	22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0578	0.0460	0.0191
Total	32	0.9675	0.9670	0.9675	0.9786	0.9786	0.9658	0.9657	0.9676	0.9657	0.9675	0.9675	0.9786

Appendix 3. Analysis of variance of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on flower quality of cut rose cv. Golden Gate

Analysis of variance	d.f.	Flower diameter (cm)											
		At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
		0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
Treatment	10	0.0038	1.6537	0.0031	1.8658	1.6537	1.5580	0.3231	0.2936	0.3164	1.0770	1.2112	1.2856
Error	22	0.0036	0.0074	0.0043	0.0046	0.0074	0.0043	0.0178	0.0164	0.0247	0.0529	0.0964	0.0729
Total	32	0.9590	0.9547	0.9657	0.9786	0.9547	0.9675	0.9765	0.9675	0.9623	0.9678	0.9549	0.9548

Appendix 4. Analysis of variance of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on flower quality of cut rose cv. Golden Gate

Analysis of variance	d.f.	Flower diameter (cm)											
		At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
		0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
Treatment	10	0.0033	0.0029	0.0015	1.4879	1.4380	1.3670	0.3455	0.4555	0.5180	1.4306	1.5797	2.2448
Error	22	0.0029	0.0029	0.0022	0.0039	0.0048	0.0045	0.0147	0.0252	0.0137	0.0361	0.0499	0.0334
Total	32	0.9675	0.9675	0.9658	0.9786	0.9675	0.9675	0.9786	0.9576	0.9657	0.9786	0.9675	0.9678

Appendix 5. **Analysis of variance of gamma irradiations (0.025 and 0.05 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^{0}C) on water uptake of cut rose cv. Golden Gate**

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)											
		1		2		3		4		5		6	
		0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05
Treatment	10	0.3273	0.3869	1.3005	2.0074	5.0519	2.6039	8.8772	4.8581	21.1391	7.3514	124.2575	112.1079
Error	22	0.0086	0.0021	0.0216	0.0117	0.0299	0.0784	0.1430	0.1371	0.1259	0.1449	0.2715	0.1102
Total	32	0.9547	0.9786	0.9786	0.9786	0.9786	0.9678	0.9678	0.9786	0.9786	0.9687	0.9677	0.9870

Appendix contd……

Appendix contd……

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)									
		7		8		9		10		11	
		0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05
Treatment	10	262.0806	147.7275	419.1702	410.0323	657.4481	617.1850	691.2052	712.1851	634.9844	737.1908
Error	22	0.1245	0.3937	0.3390	0.2040	0.1670	0.2886	0.1297	0.1807	0.1211	0.1605
Total	32	0.9786	0.9786	0.9678	0.9786	0.9786	0.9687	0.9786	0.9786	0.9786	0.9786

Appendix 6. Analysis of variance of gamma irradiations (0.10 and 0.20 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on water uptake of cut rose cv. Golden Gate

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)											
		1		2		3		4		5		6	
		0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20
Treatment	10	0.5011	0.6465	2.4211	2.9348	7.1048	8.2282	11.8152	13.9006	25.3230	212.8655	175.6382	223.6356
Error	22	0.0035	0.0036	0.0324	0.0365	0.0668	0.0480	0.0685	0.1454	0.1009	0.1465	0.2029	0.1822
Total	32	0.9687	0.9658	0.9765	0.9675	0.9677	0.9876	0.9786	0.9678	0.9788	0.9786	0.9786	0.9678

Appendix contd……

Appendix contd……

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)						
		7		8		9		10
		0.10	0.20	0.10	0.20	0.10	0.20	0.10
Treatment	10	223.5793	334.6428	430.0478	441.3423	539.1878	491.3709	531.9461
Error	22	0.2632	0.1978	0.1623	0.2165	0.1009	0.1068	0.1014
Total	32	0.9678	0.9786	0.9786	0.9786	0.9870	0.9786	0.9786

Appendix 7. Analysis of variance of gamma irradiations (0.40 and 0.60 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on water uptake of cut rose cv. Golden Gate

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)							
		1		2		3		4	
		0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60
Treatment	10	0.7657	0.0246	3.4349	4.0714	7.0478	9.3557	19.2640	45.0031
Error	22	0.0030	0.0027	0.0244	0.0223	0.0553	0.0430	0.0891	0.1005
Total	32	0.9786	0.9786	0.9786	0.9786	0.9786	0.9786	0.9786	0.9678

Appendix contd……

Appendix contd……

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)					
		7		8		9	
		0.40	0.60	0.40	0.60	0.40	0.60
Treatment	10	117.1078	134.2585	272.8215	218.4714	343.1310	303.8043
Error	22	0.1195	0.0800	0.1369	0.0807	0.1684	0.1468
Total	32	0.9786	0.9870	0.9786	0.9786	0.9786	0.9786

Appendix 8. **Analysis of variance of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Mercedes**

Analysis of variance	d.f.	Changes in fresh weight (g)								
		After cold storage			On 3rd day in vase			On senescence day in vase		
		0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
Treatment	10	0.3306	0.3035	0.1834	0.2234	0.2090	0.1057	0.8514	0.8423	0.0085
Error	22	0.0006	0.0006	0.0004	0.0013	0.0011	0.0006	0.0018	0.0006	0.0000
Total	32	0.9675	0.9675	0.9786	0.9657	0.9675	0.9677	0.9547	0.9780	0.9675

Appendix contd......

Appendix contd.......

Analysis of variance	d.f.	Changes in dry weight (g)									Vase life (days)		
		After cold storage			On 3rd day in vase			On senescence day in vase			0.025	0.05	0.10
		0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10			
Treatment	10	0.0087	0.0136	0.0085	0.0096	0.0089	0.0048	0.0378	9.0776	0.0387	9.4963	0.0007	8.9518
Error	22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0463	0.0001	0.0701	0.0820	0.0456
Total	32	0.9786	0.9675	0.9675	0.9675	0.9675	0.9680	0.9675	0.9678	0.9678	0.9675	0.9587	0.9780

Appendix 9. Analysis of variance of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Mercedes

Analysis of variance	d.f.	Changes in fresh weight (g)								
		After cold storage			On 3rd day in vase			On senescence day in vase		
		0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
Treatment	10	0.0552	0.0457	0.0228	0.0605	0.0630	0.0413	0.8634	0.8752	0.8954
Error	22	0.0001	0.0001	0.0000	0.0003	0.0002	0.0002	0.0015	0.0012	0.0013
Total	32	0.9786	0.9657	0.9678	0.9780	0.9675	0.9657	0.9678	0.9780	0.9780

Appendix contd…….

Appendix contd…….

Analysis of variance	d.f.	Changes in dry weight (g)									Vase life (days)		
		After cold storage			On 3rd day in vase			On senescence day in vase			0.20	0.40	0.60
		0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60			
Treatment	10	0.2971	0.0019	0.0011	0.0029	0.0031	0.0020	0.0029	0.0390	0.0400	0.0306	0.3920	7.4184
Error	22	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0001	0.0001	0.0358	0.0316
Total	32	0.9786	0.9786	0.9678	0.9788	0.9780	0.9786	0.9788	0.9675	0.9678	0.9786	0.9786	0.9670

Appendix 10. **Analysis of variance of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on flower quality of cut rose cv. Mercedes**

Analysis of variance	d.f.	Flower diameter (cm)											
		At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
		0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
Treatment	10	0.0008	1.4437	0.0060	1.5199	0.1833	1.3872	0.1834	0.2605	0.1748	0.2672	9.0776	0.2743
Error	22	0.0016	0.0031	0.0102	0.0050	0.0203	0.0033	0.0205	0.0490	0.0134	0.0501	0.0663	0.0435
Total	32	0.9768	0.9675	0.9675	0.9675	0.9670	0.9678	0.9675	0.9677	0.9678	0.9675	0.9678	0.9657

Appendix 11. **Analysis of variance of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on flower quality of cut rose cv. Mercedes**

Analysis of variance	d.f.	Flower diameter (cm)											
		At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
		0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
Treatment	10	0.0008	0.0008	0.0006	1.3131	1.8053	1.2040	0.1622	0.1433	0.1774	0.2519	0.3094	0.2846
Error	22	0.0021	0.0014	0.0020	0.0034	0.0027	0.0031	0.0143	0.0187	0.0137	0.0478	0.0350	0.0317
Total	32	0.9670	0.9676	0.9678	0.9786	0.9657	0.9786	0.9786	0.9678	0.9675	0.9675	0.9786	0.9676

Appendix 12. Analysis of variance of gamma irradiations (0.025 and 0.05 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on water uptake of cut rose cv. Mercedes

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)											
		1		2		3		4		5		6	
		0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05
Treatment	10	0.4219	0.5423	1.5297	1.6654	4.2980	21.4178	7.4574	28.6282	22.3885	42.6877	125.3657	132.7639
Error	22	0.0048	0.0035	0.0402	0.0429	0.1113	0.1400	0.1380	0.1647	0.1780	0.1690	0.3183	0.2153
Total	32	0.9576	0.9786	0.9678	0.9657	0.9657	0.9590	0.9790	0.9657	0.9678	0.9786	0.9677	0.9786

Appendix contd.......

Appendix contd.......

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)							
		7		8		9		10	
		0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05
Treatment	10	328.8298	333.2923	363.0952	351.4075	562.8543	529.5701	258.9039	476.5360
Error	22	0.2559	0.1581	0.1782	0.2723	0.1452	0.3073	0.1479	0.2087
Total	32	0.9678	0.9786	0.9786	0.9678	0.9780	0.9678	0.9786	0.9677

Appendix 13. Analysis of variance of gamma irradiations (0.10 and 0.20 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on water uptake of cut rose cv. Mercedes

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)											
		1		2		3		4		5		6	
		0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20
Treatment	10	0.5327	0.5097	1.7141	3.1108	10.0845	10.1567	28.4931	25.2310	51.0247	224.6946	197.2514	264.7833
Error	22	0.0031	0.0032	0.0173	0.0261	0.0629	0.0630	0.1052	0.1009	0.2219	0.2421	0.2113	0.2004
Total	32	0.9678	0.9677	0.9786	0.9677	0.9678	0.9786	0.9677	0.9678	0.9677	0.9677	0.9675	0.9786

Appendix contd.......

Appendix contd.......

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)			
		7		8	
		0.10	0.20	0.10	0.20
Treatment	10	48.6925	417.2733	15.0584	394.5185
Error	22	0.3629	0.2042	0.2404	0.1074
Total	32	0.9768	0.9677	0.9786	0.9675

Appendix 14. Analysis of variance of gamma irradiations (0.40 and 0.60 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on water uptake of cut rose cv. Mercedes

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)														
		1		2		3		4		5		6		7		8
		0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40
Treatment	10	0.5981	0.7366	2.6738	3.6933	9.6760	10.1577	24.0904	29.6111	75.6088	102.7717	193.7829	175.8171	200.1773	282.5530	339.4774
Error	22	0.0023	0.0023	0.0257	0.0197	0.0641	0.0641	0.1325	0.1154	0.1692	0.1000	0.1438	0.1308	0.1696	0.1349	0.1613
Total	32	0.9870	0.9675	0.9786	0.9786	0.9677	0.9676	0.9678	0.9675	0.9678	0.9786	0.9786	0.9677	0.9678	0.9786	0.9786

Appendix 15. Analysis of variance of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Noblesse

Analysis of variance	d.f.	Changes in fresh weight (g)								
		After cold storage			On 3rd day in vase			On senescence day in vase		
		0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
Treatment	10	0.2662	0.2469	0.1669	0.2130	0.1799	0.1410	0.8842	0.9837	1.0612
Error	22	0.0008	0.0083	0.0002	0.0010	0.0005	0.0004	0.0013	0.0012	0.0019
Total	32	0.8675	0.9786	0.9678	0.9547	0.9678	0.9677	0.9678	0.9676	0.9678

Appendix contd………

Appendix contd………

Analysis of variance	d.f.	Changes in dry weight (g)									Vase life (days)		
		After cold storage			On 3rd day in vase			On senescence day in vase					
		0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
Treatment	10	0.0120	0.0108	0.0071	0.0069	0.0081	0.0067	0.0394	0.8447	0.0478	12.0775	13.1398	14.6222
Error	22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0848	0.0345	0.0481
Total	32	0.9680	0.9687	0.9678	0.9786	0.9786	0.9678	0.9676	0.9786	0.9780	0.9676	0.9786	0.9678

Appendix 16. **Analysis of variance of gamma irradiations (0.20, 0.40, and 0.10 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Noblesse**

Analysis of variance	d.f.	Changes in fresh weight (g)								
		After cold storage			On 3rd day in vase			On senescence day in vase		
		0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
Treatment	10	0.0940	0.0640	0.0470	0.0645	0.0413	0.0348	1.0199	1.0385	1.0660
Error	22	0.0001	0.0001	0.0001	0.0003	0.0001	0.0002	0.0014	0.0016	1.0029
Total	32	0.9657	0.9786	0.9765	0.9786	0.9786	0.9768	0.9678	0.9658	0.9587

Appendix contd………

Appendix contd………

Analysis of variance	d.f.	Changes in dry weight (g)									Vase life (days)		
		After cold storage			On 3rd day in vase			On senescence day in vase					
		0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
Treatment	10	0.0040	0.0031	0.0022	0.0027	0.0022	0.0017	0.0905	0.0468	0.0469	12.1074	12.6866	12.7900
Error	22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0390	0.0433	0.0305
Total	32	0.9678	0.9786	0.9780	0.9786	0.9786	0.9780	0.9786	0.9857	0.9750	0.9675	0.9677	0.978[illegible]

Appendix 17. Analysis of variance of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on flower quality of cut rose cv. Noblesse

Analysis of variance	d.f.	Flower diameter (cm)											
		At harvest			After cold storage			On 3rd days in vase			On complete flower opening		
		0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
Treatment	10	0.0012	0.0021	0.0022	1.7260	1.4958	1.4197	0.3033	0.4479	0.4528	1.3853	1.4302	1.5956
Error	22	0.0023	0.0019	0.0020	0.0055	0.0035	0.0031	0.0213	0.0207	0.0209	0.0384	0.0502	0.0374
Total	32	0.9675	0.9678	0.9786	0.9676	0.9678	0.9678	0.9676	0.9676	0.9657	0.9780	0.9676	0.9765

Appendix 18. Analysis of variance of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on flower quality of cut rose cv. Noblesse

Analysis of variance	d.f.	Flower diameter (cm)											
		At harvest			After cold storage			On 3rd days in vase			On complete flower opening		
		0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
Treatment	10	0.0018	0.0015	0.0016	1.3565	1.3039	1.2359	0.5386	0.4881	0.5920	1.6518	1.7049	2.2580
Error	22	0.0026	0.0026	0.0026	0.0029	0.0028	0.0027	0.0148	0.0232	0.0187	0.0340	0.0308	0.0328
Total	32	0.9677	0.9677	0.9678	0.9678	0.9677	0.9678	0.9765	0.9587	0.9780	0.9786	0.9678	0.9786

Appendix 19. Analysis of variance of gamma irradiations (0.025 and 0.05 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on water uptake of cut rose cv. Noblesse

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)											
		1		2		3		4		5		6	
		0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05
Treatment	10	0.3331	03031	1.3204	2.1152	4.6116	3.2542	7.2472	9.2404	12.6572	20.3308	112.2017	116.5753
Error	22	0.0058	0.0038	0.0422	0.0400	0.0800	0.0733	0.1362	0.1898	0.3131	0.1138	0.3861	0.2520
Total	32	0.9607	0.9786	0.9675	0.9675	0.9675	0.9786	0.9675	0.9678	0.9786	0.9786	0.9657	0.9675

Appendix contd……

Appendix contd……

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)									
		7		8		9		10		11	
		0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05
Treatment	10	28.8768	248.2336	277.4213	372.1852	501.3329	548.4898	627.5593	616.8310	607.5396	597.9261
Error	22	0.3746	0.4152	0.4566	0.3341	0.6855	0.4970	0.2817	0.2263	0.1921	0.2136
Total	32	0.9675	0.9676	0.9678	0.9755	0.9568	0.9507	0.9786	0.9786	0.9870	0.9786

Appendix 20. Analysis of variance of gamma irradiations (0.10 and 0.20 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on water uptake of cut rose cv. Noblesse

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)											
		1		2		3		4		5		6	
		0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20
Treatment	10	0.4411	0.6201	3.0252	3.5672	6.9670	8.2618	14.0938	18.6688	31.4458	77.7054	178.8485	219.7129
Error	22	0.0035	0.0044	0.0415	0.0234	0.0899	0.1074	0.1161	0.2219	0.1699	0.1565	0.2118	0.1781
Total	32	0.9786	0.9678	0.9567	0.9676	0.9678	0.9587	0.9675	0.9657	0.9786	0.9768	0.9780	0.9657

Appendix contd.......

Appendix contd.......

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)						
		7		8		9		10
		0.10	0.20	0.10	0.20	0.10	0.20	0.10
Treatment	10	301.1952	375.5949	412.9133	438.6534	521.3515	504.2974	509.1170
Error	22	0.2403	0.2674	0.2512	0.3197	0.3451	0.3394	0.2213
Total	32	0.9678	0.9668	0.9780	0.9588	0.9870	0.9676	0.9678

Appendix 21. Analysis of variance of gamma irradiations (0.40 and 0.60 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^0C) on water uptake of cut rose cv. Noblesse

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)											
		1		2		3		4		5		6	
		0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60
Treatment	10	1.3775	0.8323	3.7213	4.1621	13.3545	11.2379	35.2978	48.8762	145.7269	128.3879	265.3826	234.1845
Error	22	0.0042	0.0025	0.0433	0.0215	0.0649	0.0610	0.1102	0.1014	0.1561	0.1913	0.1644	0.2867
Total	32	0.9675	0.9780	0.9587	0.9786	0.9757	0.9675	0.9678	0.9676	0.9657	0.9547	0.9698	0.9587

Appendix contd.......

Appendix contd.......

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)				
		7		8		9
		0.40	0.60	0.40	0.60	0.40
Treatment	10	349.5699	283.6925	374.5009	341.1500	351.8988
Error	22	0.1703	0.2726	0.2154	0.1646	0.1662
Total	32	0.9657	0.9657	0.9678	0.9687	0.9657

Appendix 22. **Analysis of variance of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Golden Gate**

Analysis of variance	d.f.	Changes in fresh weight (g)								
		After cold storage			On 3rd day in vase			On senescence day in vase		
		0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
Treatment	10	0.7786	0.7298	0.6743	0.4797	0.4534	0.4251	0.9189	0.9088	0.8896
Error	22	0.0012	0.0011	0.0010	0.0010	0.0015	0.0014	0.0013	0.0010	0.0015
Total	32	0.9675	0.9780	0.9786	0.9786	0.9786	0.9786	0.9760	0.9678	0.9760

Appendix contd………

Appendix contd………

Analysis of variance	d.f.	Changes in dry weight (g)									Vase life (days)		
		After cold storage			On 3rd day in vase			On senescence day in vase					
		0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
Treatment	10	0.0357	0.0319	0.0304	0.0211	0.0205	0.8184	0.0421	0.0412	0.0422	19.3559	17.9098	15.4887
Error	22	0.0000	0.0000	0.0000	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000	0.0627	0.0390	0.0270
Total	32	0.9786	0.9677	0.9678	0.9687	0.9678	0.9786	0.9786	0.9870	0.9678	0.9878	0.9786	0.9786

Appendix 23. Analysis of variance of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and dry cold storage (2^{0}C) on changes in wet and dry weights, and vase lives of cut rose cv. Golden Gate

Analysis of variance	d.f.	Changes in dry weight (g)								
		After cold storage			On 3rd day in vase			On senescence day in vase		
		0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
Treatment	10	0.3776	0.2316	0.1282	0.1397	0.0721	0.0924	0.8811	0.9153	0.9455
Error	22	0.0006	0.0002	0.0001	0.0008	0.0003	0.0002	0.0008	0.0009	0.0010
Total	32	0.9676	0.9768	0.9687	0.9658	0.9786	0.9786	0.9786	0.9768	0.9786

Appendix contd………

Appendix contd………

Analysis of variance	d.f.	Changes in dry weight (g)									Vase life (days)		
		After cold storage			On 3rd day in vase			On senescence day in vase					
		0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
Treatment	10	0.0173	0.0103	0.0061	0.0059	0.0032	0.0044	0.0399	0.0417	0.0437	13.3217	11.0325	8.5571
Error	22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0378	0.0385	0.0227
Total	32	0.9768	0.9678	0.9867	0.9768	0.9768	0.9767	0.9768	0.9786	0.9855	0.9723	0.9687	0.9768

Appendix 24. **Analysis of variance of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on flower quality of cut rose cv. Golden Gate**

Analysis of variance	d.f.	Flower diameter (cm)											
		At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
		0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
Treatment	10	0.0004	0.0007	0.0007	4.1610	4.0033	3.8576	0.3019	0.3133	0.3689	0.6973	0.6513	0.7395
Error	22	0.0013	0.0013	0.0008	0.0042	0.0081	0.0115	0.0160	0.0098	0.0099	0.0451	0.0255	0.0384
Total	32	0.9786	0.9786	0.9786	0.9870	0.9678	0.9676	0.9678	0.9800	0.9786	0.9786	0.9786	0.9678

Appendix 25. **Analysis of variance of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on flower quality of cut rose cv. Golden Gate**

Analysis of variance	d.f.	Flower diameter (cm)											
		At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
		0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
Treatment	10	0.0008	0.0010	0.0007	3.6603	3.4072	3.1840	0.3384	0.3221	0.3826	0.8588	0.8045	0.8481
Error	22	0.0014	0.0022	0.0010	0.0034	0.0045	0.0063	0.0139	0.0139	0.0148	0.0280	0.0414	0.0324
Total	32	0.9768	0.9786	0.9786	0.9870	0.9786	0.9687	0.9687	0.9687	0.9786	0.9760	0.9786	0.9687

Appendix 26. Analysis of variance of gamma irradiations (0.025 and 0.05 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on water uptake of cut rose cv. Golden Gate

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)											
		1		2		3		4		5		6	
		0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05
Treatment	10	0.4525	0.4879	2.4747	2.8795	11.0003	10.9683	16.3595	16.4201	33.7971	34.0731	58.7549	59.4902
Error	22	0.0023	0.0028	0.0120	0.0192	0.0529	0.0278	0.0842	0.1297	0.4360	0.1209	0.1618	0.1703
Total	32	0.9786	0.9786	0.9786	0.9786	0.9768	0.9786	0.9786	0.9670	0.9656	0.9786	0.9786	0.9768

Appendix contd……

Appendix contd……

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)										
		7		8		9		10		11		12
		0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025
Treatment	10	181.4482	285.0611	355.2857	467.4996	694.1941	613.3408	760.6555	742.8330	818.0591	769.0140	776.7534
Error	22	0.3227	0.2896	0.1678	0.2893	0.2792	0.3154	0.1971	0.1841	0.0602	0.1757	0.1273
Total	32	0.9658	0.9870	0.9876	0.9786	0.9687	0.9687	0.9800	0.9768	0.9870	0.9786	0.9790

Appendix 27. Analysis of variance of gamma irradiations (0.10 and 0.20 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on water uptake of cut rose cv. Golden Gate

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)											
		1		2		3		4		5		6	
		0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20
Treatment	10	0.4866	0.5756	2.9642	3.0764	11.1531	10.9764	16.0146	20.9610	35.5626	43.8548	134.7972	218.1526
Error	22	0.0018	0.0041	0.0258	0.0287	0.0940	0.0463	0.0811	0.1125	0.1950	0.1143	0.2854	0.2126
Total	32	0.9786	0.9658	0.9734	0.9670	0.9734	0.9786	0.9786	0.9687	0.9658	0.9786	0.9765	0.9678

Appendix contd……

Appendix contd……

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)						
		7		8		9		10
		0.10	0.20	0.10	0.20	0.10	0.20	0.10
Treatment	10	281.6617	278.2883	451.0633	514.6489	631.3839	602.3826	660.0033
Error	22	0.2807	0.1780	0.2484	0.3176	0.2641	0.1375	0.1208
Total	32	0.9678	0.9786	0.9734	0.9786	0.9677	0.9786	0.9760

Appendix 28. Analysis of variance of gamma irradiations (0.40 and 0.60 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on water uptake of cut rose cv. Golden Gate

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)							
		1		2		3		4	
		0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60
Treatment	10	0.5864	0.5177	3.0910	1.4158	10.6281	7.5667	19.9824	17.7920
Error	22	0.0034	0.0029	0.0402	0.0135	0.0828	0.0417	0.1650	0.1124
Total	32	0.9687	0.9687	0.9675	0.9834	0.9756	0.9876	0.9567	0.9657

Appendix contd…….

Appendix contd…….

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)								
		5		6		7		8		9
		0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40
Treatment	10	43.9365	39.6849	208.3350	250.0208	348.7020	301.4103	470.5612	428.6946	566.7558
Error	22	0.1900	0.1364	0.2434	0.1202	0.2734	0.1331	0.1381	0.0856	0.1817
Total	32	0.9734	0.9709	0.9786	0.9768	0.9786	0.9786	0.9845	0.9846	0.9760

Appendix 29. **Analysis of variance of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Mercedes**

Analysis of variance	d.f.	Changes in fresh weight (g)								
		After cold storage			On 3rd day in vase			On senescence day in vase		
		0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
Treatment	10	0.9292	0.8415	0.5815	1.1310	0.9300	0.5555	0.8115	0.8048	0.0116
Error	22	0.0011	0.0006	0.0004	0.0018	0.0006	0.0016	0.0005	0.0009	0.0006
Total	32	0.9675	0.9786	0.9786	0.9675	0.9786	0.9677	0.9786	0.9786	0.9786

Appendix contd.....

Appendix contd.....

Analysis of variance	d.f.	Changes in dry weight (g)									Vase life (days)		
		After cold storage			On 3rd day in vase			On senescence day in vase			0.025	0.05	0.10
		0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10			
Treatment	10	0.0416	0.0379	0.0253	0.0521	0.0417	0.0258	0.0355	0.0345	0.0351	8.0104	6.7243	5.8578
Error	22	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0000	0.0000	0.0000	0.0368	0.0348	0.0533
Total	32	0.9677	0.9678	0.9675	0.9677	0.9786	0.9677	0.9786	0.9786	0.9870	0.9786	0.9786	0.9677

Appendix 30. **Analysis of variance of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Mercedes**

Analysis of variance	d.f.	Changes in fresh weight (g)								
		After cold storage			On 3rd day in vase			On senescence day in vase		
		0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
Treatment	10	0.3405	0.1561	0.0500	0.2423	0.0961	0.0567	0.0439	0.8836	0.9113
Error	22	0.0005	0.0003	0.0001	0.0008	0.0004	0.0002	0.0016	0.0008	0.0008
Total	32	0.9786	0.9675	0.9657	0.9786	0.9786	0.9786	0.9670	0.9786	0.9786

Appendix contd.....

Appendix contd.....

Analysis of variance	d.f.	Changes in dry weight (g)									Vase life (days)		
		After cold storage			On 3rd day in vase			On senescence day in vase					
		0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
Treatment	10	0.0149	0.0070	0.0021	0.0109	0.0045	0.0029	0.0385	0.0380	0.0410	5.6580	7.4725	6.0501
Error	22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0001	0.0279	0.0379	0.0332
Total	32	0.9675	0.9677	0.9677	0.9680	0.9786	0.9786	0.9786	0.9670	0.9675	0.9786	0.9677	0.9876

Appendix 31. **Analysis of variance of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on flower quality of cut rose cv. Mercedes**

Analysis of variance	d.f.	Flower diameter (cm)											
		At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
		0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
Treatment	10	0.0033	0.0021	0.0018	3.7032	0.9862	3.4285	0.2151	0.2105	0.2015	0.3584	0.6147	0.2042
Error	22	0.0007	0.0021	0.0014	0.0075	0.0084	0.0102	0.0096	0.0165	0.0208	0.0230	0.0402	0.0222
Total	32	0.9876	0.9678	0.9677	0.9675	0.9677	0.9675	0.9786	0.9786	0.9670	0.9786	0.9786	0.9786

Appendix 32. **Analysis of variance of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on flower quality of cut rose cv. Mercedes**

Analysis of variance	d.f.	Flower diameter (cm)											
		At harvest			After cold storage			On 3rd day in vase			On complete flower opening		
		0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
Treatment	10	0.0019	0.0010	0.0008	3.2907	3.1585	2.9982	0.1729	0.1637	0.1381	0.3321	0.3078	0.2647
Error	22	0.0015	0.0014	0.0021	0.0098	0.0070	0.0067	0.0200	0.0157	0.0182	0.0609	0.0242	0.0201
Total	32	0.9677	0.9678	0.9675	0.9675	0.9786	0.9786	0.9675	0.9786	0.9675	0.9600	0.9675	0.9786

Appendix 33. Analysis of variance of gamma irradiations (0.025 and 0.05 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on water uptake of cut rose cv. Mercedes

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)											
		1		2		3		4		5		6	
		0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05
Treatment	10	0.3731	0.3658	0.4815	0.4598	2.8899	2.7737	4.5975	4.3474	7.0276	12.3320	17.3151	28.9674
Error	22	0.0062	0.0060	0.0470	0.0305	0.0950	0.0819	0.1408	0.2024	0.2373	0.2083	0.4149	0.2657
Total	32	0.9675	0.9675	0.9675	0.9677	0.9786	0.9670	0.9670	0.9675	0.9786	0.9657	0.9677	0.9675

Appendix contd.....

Appendix contd.....

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)						
		7		8		9		10
		0.025	0.05	0.025	0.05	0.025	0.05	0.025
Treatment	10	173.0565	176.5270	358.2966	338.9388	534.4400	518.6200	696.0217
Error	22	0.3766	0.3483	0.4245	0.2256	0.5881	0.4496	0.3864
Total	32	0.9786	0.9657	0.9786	0.9786	0.9657	0.9678	0.9657

Appendix 34. Analysis of variance of gamma irradiations (0.10 and 0.20 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on water uptake of cut rose cv. Mercedes

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)											
		1		2		3		4		5		6	
		0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20
Treatment	10	0.3469	0.3620	0.4234	0.4874	3.1124	2.8228	5.3706	5.8895	14.5320	15.1625	29.7168	37.2019
Error	22	0.0037	0.0030	0.0336	0.0182	0.0776	0.0864	0.0835	0.1279	0.2199	0.2758	0.2932	0.2366
Total	32	0.9677	0.9786	0.9786	0.9786	0.9675	0.9786	0.9786	0.9670	0.9786	0.9675	0.9786	0.9870

Appendix contd.....

Appendix contd.....

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)					
		7		8		9	
		0.10	0.20	0.10	0.20	0.10	0.20
Treatment	10	172.5537	283.0424	325.3540	395.6705	588.4511	525.3166
Error	22	0.4619	0.1801	0.3729	0.4365	0.2427	0.2772
Total	32	0.9677	0.9786	0.9786	0.1965	0.9677	0.9675

Appendix 35. Analysis of variance of gamma irradiations (0.40 and 0.60 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on water uptake of cut rose cv. Mercedes

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)							
		1		2		3		4	
		0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60
Treatment	10	0.3090	0.2783	0.4377	0.5840	2.4654	2.6360	4.4357	11.1403
Error	22	0.0045	0.0026	0.0408	0.0388	0.1886	0.0971	0.1244	0.1647
Total	32	0.9675	0.9870	0.9675	0.9670	0.9675	0.9675	0.9675	0.9675

Appendix contd.....

Appendix contd.....

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)							
		5		6		7		8	
		0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60
Treatment	10	16.6702	29.3930	130.6003	191.5451	353.3078	296.1115	452.4660	412.9599
Error	22	0.1752	0.2405	0.1458	0.1789	0.1569	0.2445	0.2259	0.2178
Total	32	0.9677	0.9670	0.9786	0.9670	0.9786	0.9765	0.9675	0.9675

Appendix 36. Analysis of variance of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^{0}C) on changes in fresh and dry weights, and vase lives of cut rose cv. Noblesse

Analysis of variance	d.f.	Changes in fresh weight (g)								
		After cold storage			On 3rd day in vase			On senescence day in vase		
		0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
Treatment	10	0.8484	0.7876	0.5086	0.7081	0.6643	0.3760	0.8537	0.8631	0.8570
Error	22	0.0017	0.0011	0.0008	0.0021	0.0019	0.0011	0.0012	0.0013	0.0011
Total	32	0.9675	0.9786	0.9657	0.9587	0.9677	0.9657	0.9786	0.9786	0.9678

Appendix contd.........

Appendix contd.........

Analysis of variance	d.f.	Changes in dry weight (g)									Vase life (days)		
		After cold storage			On 3rd day in vase			On senescence day in vase					
		0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
Treatment	10	0.0379	0.0359	0.0228	0.0293	0.0285	0.0168	0.0387	0.0393	0.0379	16.5445	13.9398	12.0844
Error	22	0.0001	0.0001	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0001	0.0977	0.0376	0.0518
Total	32	0.9786	0.9675	0.9786	0.9657	0.9680	0.9875	0.9768	0.9675	0.9675	0.9657	0.9786	0.9678

Appendix 37. **Analysis of variance of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on changes in fresh and dry weights, and vase lives of cut rose cv. Noblesse**

Analysis of variance	d.f.	Changes in fresh weight (g)								
		After cold storage			On 3rd day in vase			On senescence day in vase		
		0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
Treatment	10	0.2814	0.1840	0.0951	0.1365	0.1127	0.0628	0.9541	1.0241	1.0466
Error	22	0.0006	0.0002	0.0001	0.0009	0.0002	0.0001	0.0014	0.0019	0.0016
Total	32	0.9677	0.9675	0.9670	0.9677	0.9856	0.9786	0.9675	0.9678	0.9678

Appendix contd………

Appendix contd………

Analysis of variance	d.f.	Changes in dry weight (g)									Vase life (days)		
		After cold storage			On 3rd day in vase			On senescence day in vase					
		0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
Treatment	10	0.0126	0.0081	0.0039	0.0059	0.0052	0.0029	0.0441	0.0459	0.0472	11.0657	8.2504	7.4285
Error	22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0416	0.0536	0.0247
Total	32	0.9675	0.9675	0.9786	0.9786	0.9786	0.9786	0.9786	0.9880	0.9677	0.9687	0.9768	0.9786

Appendix 38. **Analysis of variance of gamma irradiations (0.025, 0.05, and 0.10 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on flower quality of cut rose cv. Noblesse**

Analysis of variance	d.f.	Flower diameter (cm)											
		At harvest			After cold storage			On 3rd days in vase			On complete flower opening		
		0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10	0.025	0.05	0.10
Treatment	10	0.0010	0.0013	0.0021	3.9457	3.8279	3.6772	0.2846	0.2719	0.3107	0.4785	0.4276	0.4014
Error	22	0.0012	0.0018	0.0021	0.0117	0.0089	0.0082	0.0171	0.0094	0.0141	0.0569	0.0434	0.0424
Total	32	0.9786	0.9678	0.9786	0.9676	0.9768	0.9786	0.9786	0.9786	0.9675	0.9678	0.9780	0.9786

Appendix 39. **Analysis of variance of gamma irradiations (0.20, 0.40, and 0.60 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on flower quality of cut rose cv. Noblesse**

Analysis of variance	d.f.	Flower diameter (cm)											
		At harvest			After cold storage			On 3rd days in vase			On complete flower opening		
		0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60	0.20	0.40	0.60
Treatment	10	0.0010	0.0018	0.0029	3.4735	3.3228	3.1757	0.8606	0.2725	0.2338	0.9641	0.7379	0.7175
Error	22	0.0018	0.0013	0.0012	0.0046	0.0044	0.0065	0.0094	0.0087	0.0126	0.0352	0.0330	0.0316
Total	32	0.9678	0.9768	0.9780	0.9786	0.9786	0.9677	0.9768	0.9786	0.9675	0.9675	0.9675	0.987

Appendix 40. Analysis of variance of gamma irradiations (0.025 and 0.05 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on water uptake of cut rose cv. Noblesse

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)											
		1		2		3		4		5		6	
		0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05
Treatment	10	0.4878	0.4463	0.7739	2.6728	11.0833	11.4336	18.0387	17.9018	34.1762	34.1874	56.2294	55.2244
Error	22	0.0042	0.0061	0.0308	0.0186	0.0758	0.0487	0.1401	0.0823	0.2184	0.2159	0.1626	0.1628
Total	32	0.9870	0.9677	0.9677	0.9786	0.9676	0.9786	0.9808	0.9786	0.9657	0.9786	0.9786	0.9786

Appendix contd.......

Appendix contd.......

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)									
		7		8		9		10		11	12
		0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.05	0.025	0.025
Treatment	10	290.5404	208.7539	349.4332	462.7265	525.3746	520.5500	742.2809	727.1912	805.1403	749.3672
Error	22	0.2858	0.2862	0.2235	0.2084	0.2339	0.1649	0.2022	0.1663	0.2986	0.1471
Total	32	0.9678	0.9678	0.9786	0.9786	0.9786	0.9876	0.9786	0.9786	0.9677	0.9786

Appendix 41. Analysis of variance of gamma irradiations (0.10 and 0.20 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on water uptake of cut rose cv. Noblesse

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)											
		1		2		3		4		5		6	
		0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20
Treatment	10	0.4302	0.4523	2.7084	2.8623	11.6763	11.9044	17.8197	21.9842	30.3027	42.6704	51.3867	136.6925
Error	22	0.0025	0.0036	0.0132	0.0261	0.0477	0.0491	0.0813	0.1341	0.1219	0.1682	0.1600	0.1420
Total	32	0.9786	0.9678	0.9876	0.9687	0.9786	0.9768	0.9786	0.9786	0.9786	0.9870	0.9786	0.9786

Appendix contd.......

Appendix contd.......

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)							
		7		8		9		10	
		0.10	0.20	0.10	0.20	0.10	0.20	0.10	0.20
Treatment	10	285.4637	356.2448	458.6144	504.8700	508.5369	592.4883	660.5730	585.0267
Error	22	0.2832	0.2428	0.1480	0.3102	0.3489	0.2888	0.2399	0.1285
Total	32	0.9677	0.9675	0.9876	0.9786	0.9677	0.9786	0.9786	0.9786

Appendix 42. **Analysis of variance of gamma irradiations (0.40 and 0.60 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on water uptake of cut rose cv. Noblesse**

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)											
		1		2		3		4		5		6	
		0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60	0.40	0.60
Treatment	10	0.5085	0.4455	3.1452	2.8979	11.7304	10.8728	20.2976	19.1315	41.6471	43.2122	128.8692	175.6048
Error	22	0.0022	0.0050	0.0168	0.0240	0.0434	0.0796	0.0710	0.0913	0.1069	0.0902	0.3051	0.1531
Total	32	0.9786	0.9677	0.9786	0.9687	0.9786	0.9786	0.9786	0.9676	0.9786	0.9786	0.9677	0.9677

Appendix contd.......

Appendix contd.......

Analysis of variance	d.f.	Water uptake (ml) in days after keeping cut flowers in vase (water)					
		7		8		9	
		0.40	0.60	0.40	0.60	0.40	0.60
Treatment	10	338.9523	216.8555	510.8013	432.9191	533.6412	436.3300
Error	22	0.3414	0.1245	0.1395	0.2131	0.1217	0.0855
Total	32	0.9678	0.9786	0.9786	0.9786	0.9786	0.9786

Appendix 43. **Analysis of variance of gamma irradiation dose (0.25 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on changes in respiration rate of cut rose cv. Golden Gate**

Analysis of variance	d.f.	At harvest	After irradiation	After cold storage	On 3rd day in vase	On senescence day in vase
Treatment	10	7.1389	19.3438	563.1563	2269.1670	2369.6390
Error	22	52.1750	60.2361	31.2222	163.4250	38.7125
Total	32	0.9768	0.9780	0.9786	0.9675	0.9768

Appendix 44. **Analysis of variance of gamma irradiation dose (0.025 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on changes in total soluble sugars content of cut rose cv. Golden Gate**

Analysis of variance	d.f.	At harvest	After irradiation	After cold storage	On 3rd day in vase	On senescence day in vase
Treatment	10	13.7778	6.4375	309.2500	3965.8330	7102.0200
Error	22	73.4375	58.2778	77.3333	66.9000	89.0125
Total	32	0.9678	0.9786	0.9866	0.9786	0.9777

Appendix 45. **Analysis of variance of gamma irradiation dose (0.025 kGy), pulsing with sucrose (3 per cent) and wet cold storage (2^0C) on changes in total free amino acid content of cut rose cv. Golden Gate**

Analysis of variance	d.f.	At harvest	After irradiation	After cold storage	On 3rd day in vase	On senescence day in vase
Treatment	10	13.7465	6.9707	558.1719	663.0382	549.7640
Error	22	1.4820	1.5100	2.8498	5.1477	4.2953
Total	32	0.9768	0.9786	0.9786	0.9675	0.9786