

**EFFECT OF FLORAL PRESERVATIVES ON  
QUALITY AND VASE LIFE OF BIRD-OF-  
PARADISE (*Strelitzia reginae* Ait.)**

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**in**

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**JULY, 2011**

Affectionately dedicated to  
my PARENTS and lord GANESHA



*JEEVI*

**DEPARTMENT OF HORTICULTURE  
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**CERTIFICATE**

This is to certify that the thesis entitled “**Effect of floral preservatives on quality and vase life of bird-of-paradise (*Strelitzia reginae* Ait.)**” submitted by **Ms. JEEVITHA, S., ID. No. PHK 929**, in partial fulfillment of the requirements for the degree of **Master of Science (Horticulture)** in **Post Harvest Technology** to the University of Agricultural Sciences, Bengaluru, is a record of research work carried out by her during the period of her study in this University, under my guidance and supervision and that no part of the thesis has been submitted for the award of any degree, diploma, associate ship, fellowship or other similar titles.

**Bengaluru**

**July, 2011**

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*( JEEVITHA, S.)*

## **Effect of floral preservatives on quality and vase life of bird-of-paradise (*Strelitzia reginae* Ait.)**

### **ABSTRACT**

A study on the effect of floral preservatives on quality and vase life of bird-of-paradise cut flowers was carried out by conducting two experiments at the Department of Horticulture, Gandhi Krishi Vignana Kendra, Bangalore during 2010-2011. In the first experiment, the best stage of harvest and pulsing solution for enhancing the vase life of flowers, was studied with twelve treatments replicated thrice using Factorial Complete Randomised Design. The second experiment was on the effect of holding solution on the quality and vase life of bird-of-paradise harvested at commercial stage of harvest and the design followed was Completely Randomised Design with seventeen treatments replicated thrice.

The bird-of-paradise cut flower harvested at commercial stage S<sub>2</sub> (one floret open stage) and pulsed with P<sub>2</sub> (10% sucrose + 200ppm 8HQS +150ppm citric acid for 48 hours) recorded maximum cumulative uptake of water (87.00 g/cut flower), cumulative loss of water (90.23 g/cut flower), cumulative uptake of water : cumulative loss of water (0.96), cumulative water balance (-3.23 g/cut flower), fresh weight (119.10g) and minimum physiological loss in weight (2.67%) and also maximum additional vase life to additional cost ratio (2.53).

The results revealed that, the bird-of-paradise cut flower should be harvested at one floret open stage and pulsed with 10 per cent sucrose + 200ppm 8HQS +150ppm citric acid for 48 hours for better keeping quality and prolonged vase life of (16.00 days).

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(Major Advisor)

ಬರ್ಡ್ ಆಫ್ ಪ್ಯಾರಡೈಸ್ (ಸ್ವಿರಿಲಿಟ್ಟಿಯ ರೆಜಿನೇ) ಹೂವಿನ ಗುಣಮಟ್ಟ ಮತ್ತು ಹೂದಾನಿ ಜೀವನದ  
ಮೇಲೆ ವಿವಿಧ ಪುಷ್ಪ ಸಂರಕ್ಷಕಗಳ ಪರಿಣಾಮ

ಸಾರಾಂಶ

ಬರ್ಡ್ ಆಫ್ ಪ್ಯಾರಡೈಸ್‌ನ ಕತ್ತರಿಸಿದ ಹೂಗಳ ಮೇಲೆ ಕೊಯ್ಲಿನ ಹಂತ, ಪಲ್ನಿಂಗ್ ದ್ರಾವಣ ಮತ್ತು ಹೋಲ್ಡಿಂಗ್ ದ್ರಾವಣಗಳ ಪರಿಣಾಮವನ್ನು ಅರಿಯಲು “ಬರ್ಡ್ ಆಫ್ ಪ್ಯಾರಡೈಸ್ ಹೂವಿನ ಗುಣಮಟ್ಟ ಮತ್ತು ಹೂದಾನಿ ಜೀವನದ ಮೇಲೆ ವಿವಿಧ ಪುಷ್ಪ ಸಂರಕ್ಷಕಗಳ ಪರಿಣಾಮ” ಈ ಕುರಿತು ಎರಡು ಪ್ರಯೋಗಗಳನ್ನು ಕೃಷಿ ವಿಶ್ವವಿದ್ಯಾನಿಲಯದ ಗಾಂಧಿ ಕೃಷಿ ವಿಜ್ಞಾನ ಕೇಂದ್ರದ ತೋಟಗಾರಿಕಾ ವಿಭಾಗದಲ್ಲಿ 2010-2011 ನೇ ಸಾಲಿನಲ್ಲಿ ಕೈಗೊಳ್ಳಲಾಯಿತು. ಮೊದಲನೇ ಪ್ರಯೋಗವನ್ನು, ಹೂದಾನಿ ಜೀವನವನ್ನು ಹೆಚ್ಚಿಸಲು, ನಿಖರವಾದ ಕೊಯ್ಲಿನ ಹಂತ ಹಾಗೂ ಪಲ್ನಿಂಗ್ ದ್ರಾವಣದ ಪರಿಣಾಮವನ್ನು ಅರಿಯಲು 12 ಉಪಚಾರ ಹಾಗೂ 3 ಪ್ರತಿಕೃತಿಗಳಲ್ಲಿ, ಫ್ಯಾಕ್ಟೋರಿಯಲ್ ರ್ಯಾಂಡಮೈಸ್ಡ್ ಡಿಸನ್ ಉಪಯೋಗಿಸಲಾಗಿದೆ. ಎರಡನೇ ಪ್ರಯೋಗವನ್ನು ಹೋಲ್ಡಿಂಗ್ ದ್ರಾವಣದ ಪರಿಣಾಮವನ್ನು ಅರಿಯಲು, 17 ಉಪಚಾರ ಹಾಗೂ 3 ಪ್ರತಿಕೃತಿಗಳಲ್ಲಿ ಕಂಪ್ಲೀಟ್ ರ್ಯಾಂಡಮೈಸ್ಡ್ ಡಿಸೈನ್ ಉಪಯೋಗಿಸಿ ಕೈಗೊಳ್ಳಲಾಗಿದೆ.

ಬರ್ಡ್ ಆಫ್ ಪ್ಯಾರಡೈಸ್ ಹೂವನ್ನು ವಾಣಿಜ್ಯ ಹಂತ ಅಂದರೆ ಹೂವಿನ ಗುಚ್ಚದಲ್ಲಿ ಕೇವಲ ಒಂದು ಹೂವು ಮಾತ್ರ ತೆರೆದಿರುವ ಹಂತದಲ್ಲಿ ಕಟಾವು ಮಾಡಿ ಅನಂತರ ಅದನ್ನು 10% ಸುಕ್ರೋಸ್ + 200 ಪಿ.ಪಿ.ಎಂ 8 ಹೈಡ್ರೊಕ್ಸಿ ಕ್ಲಿನೋಲಿನ್ ಸಲ್ಫೇಟ್ + 150 ಪಿ.ಪಿ.ಎಂ ಸಿಟ್ರಿಕ್ ಆಮ್ಲದಲ್ಲಿ 48 ಗಂಟೆಗಳ ಕಾಲ ಪಲ್ನಿಂಗ್ ಮಾಡಿದಾಗ, ಈ ರೀತಿ ಉಪಚರಿಸಿದ ಹೂವುಗಳಲ್ಲಿ ಗರಿಷ್ಠ ಸಂಚಿತ ನೀರಿನ ಹೀರುವಿಕೆ (87.0 ಗ್ರಾಂ/ಹೂ), ನೀರಿನ ಸಂಚಿತ ನಷ್ಟ (92.23 ಗ್ರಾಂ / ಹೂ), ನೀರಿನ ಗರಿಷ್ಠ ಸಂಚಿತ ಹೀರುವಿಕೆ: ನೀರಿನ ಸಂಚಿತ ನಷ್ಟ (0.96), ಸಂಚಿತ ನೀರಿನ ಸಮತೋಲನ (-3.23 ಗ್ರಾಂ/ಹೂ), ತಾಜಾ ತೂಕ (119.10 ಗ್ರಾಂ) ಮತ್ತು ಕನಿಷ್ಠ ಶಾರೀರಿಕ ನಷ್ಟದ ತೂಕ (2.67%) ಮತ್ತು ಹೆಚ್ಚುವರಿ ವೆಚ್ಚ ಅನುಪಾತಕ್ಕೆ ಹೆಚ್ಚುವರಿ ಹೂದಾನಿ ಜೀವನ (2.53) ದಾಖಲಾಗಿರುವುದು ಅಧ್ಯಯನದಿಂದ ತಿಳಿದುಬಂದಿರುತ್ತದೆ.

ಮೇಲ್ಕಂಡ ಫಲಿತಾಂಶಗಳ ಪ್ರಕಾರ ಬರ್ಡ್ ಆಫ್ ಪ್ಯಾರಡೈಸ್ ಹೂವನ್ನು ಹೂಗುಚ್ಚದಲ್ಲಿ ಒಂದು ಹೂ ತೆರೆದ ಹಂತದಲ್ಲಿ ಕಟಾವು ಮಾಡಬೇಕು, ಅನಂತರ ಅದನ್ನು 10% ಸುಕ್ರೋಸ್ + 200 ಪಿ.ಪಿ.ಎಂ 8 - ಹೈಡ್ರೊಕ್ಸಿ ಕ್ಲಿನೋಲಿನ್ ಸಲ್ಫೇಟ್ + 150 ಪಿ.ಪಿ.ಎಂ ಸಿಟ್ರಿಕ್ ಆಸಿಡ್‌ನಲ್ಲಿ 48 ಗಂಟೆಗಳ ಕಾಲ ಪಲ್ನಿಂಗ್ ಮಾಡಿದಲ್ಲಿ ಉತ್ತಮ ಗುಣಮಟ್ಟ ಮತ್ತು ದೀರ್ಘಕಾಲದ ಹೂದಾನಿ ಜೀವನ ಅಂದರೆ ಗರಿಷ್ಠ 16 ದಿನಗಳನ್ನು ಪಡೆಯಬಹುದಾಗಿದೆ.

ವಿದ್ಯಾರ್ಥಿಯ ಸಹಿ  
(ಜೀವಿತಾ ಎಸ್.)

ಪ್ರಧಾನ ಮಾರ್ಗದರ್ಶಕರ ಸಹಿ  
(ಬಿ. ಎಸ್. ಶ್ರೀರಾಮು)

# CONTENTS

<b>CHAPTER No.</b>	<b>TITLE</b>	<b>PAGE No.</b>
I	INTRODUCTION	1-4
II	REVIEW OF LITERATURE	5-26
III	MATERIAL AND METHODS	27-37
IV	EXPERIMENTAL RESULTS	38-66
V	DISCUSSION	67-79
VI	SUMMARY AND CONCLUSION	80-83
VII	REFERENCES	84-97
	APPENDICES	

## LIST OF TABLES

<b>TABLE No.</b>	<b>TITLE</b>	<b>PAGE No.</b>
1	Uptake of water by bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions	39
2	Loss of water by bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions	42
3	Ratio of uptake of water and loss of water of bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions	44
4	Water balance of bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions	46
5	Fresh weight of bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions	48
6	Physiological loss in weight of bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions	50
7	Vase life of bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions	52
8	Uptake of water by bird-of-paradise cut flowers as influenced by holding solutions	55
9	Loss of water by bird-of-paradise cut flowers as influenced by holding solutions	56
10	Ratio between uptake of water and loss of water by bird-of-paradise cut flowers as influenced by holding solutions	58
11	Water balance of bird-of-paradise cut flowers as influenced by holding solutions	60
12	Fresh weight of bird-of-paradise cut flowers as influenced by holding solutions	61

<b>TABLE No.</b>	<b>TITLE</b>	<b>PAGE No.</b>
13	Physiological loss in weight of bird-of-paradise cut flowers as influenced by holding solutions	63
14	Vase life of bird-of-paradise cut flowers as influenced by holding solutions	64
15	Cost effectiveness of usage of floral preservatives in Experiment-I for enhancing the vase life of bird-of-paradise cut flowers	66

## **LIST OF FIGURES**

<b>Fig. No.</b>	<b>TITLE</b>	<b>BETWEEN PAGES</b>
1	Cumulative uptake of water by bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions	39-40
2	Cumulative loss of water by bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions	42-43
3	Cumulative physiological loss in weight of bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions	50-51
4	Vase life of bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions	52-53
5	Cumulative uptake of water by bird-of-paradise cut flowers as influenced by holding solutions	55-56
6	Cumulative loss of water by bird-of-paradise cut flowers as influenced by holding solutions	56-57
7	Cumulative physiological loss in weight of bird-of-paradise cut flowers as influenced by holding solutions	63-64
8	Vase life of bird-of-paradise cut flowers as influenced by holding solutions	64-65
9	Cost effectiveness of usage of floral preservatives in Experiment-I for enhancing the vase life of bird-of-paradise cut flowers	65-66

## LIST OF PLATES

<b>PLATE No.</b>	<b>TITLE</b>	<b>BETWEEN PAGES</b>
1	Bird-of-paradise flowers harvested at different stages	32-33
2	Bird-of-paradise cut flowers kept for pulsing	67-68
3	Bird-of-paradise cut flowers transferred to distilled water after 48 hours of pulsing	67-68
4	S <sub>2</sub> P <sub>2</sub> in Experiment-I on 15 <sup>th</sup> day	72-73
5	S <sub>2</sub> P <sub>0</sub> and S <sub>2</sub> P <sub>2</sub> in Experiment-I on 15 <sup>th</sup> day	72-73
6	S <sub>1</sub> P <sub>2</sub> , S <sub>2</sub> P <sub>2</sub> and S <sub>3</sub> P <sub>2</sub> in Experiment-I on 15 <sup>th</sup> day	73-74
7	S <sub>2</sub> P <sub>1</sub> , S <sub>2</sub> P <sub>2</sub> and S <sub>2</sub> P <sub>3</sub> in Experiment-I on 15 <sup>th</sup> day	73-74
8	General view of Experiment-II	76-77
9	T <sub>17</sub> in Experiment-II on 15 <sup>th</sup> day	76-77
10	T <sub>1</sub> and T <sub>17</sub> in Experiment-II on 15 <sup>th</sup> day	76-77



*INTRODUCTION*

## I. INTRODUCTION

Floriculture is a fast emerging major venture in the world. It provides more return per unit area than other horticultural crops. Modern day floriculture relates more to the production of high value cut flower crops such as rose, gladiolus, carnation, anthurium, gerbera, chrysanthemum, orchids, liliiums, bird-of-paradise etc. Total floriculture trade in the world is >60 billion US dollars. The floriculture industry is growing at a rate of 17 per cent per annum. The major exporting countries are Netherland, Columbia, Italy, Israel, Thailand, France, Spain, Kenya, Japan, Germany, United States and South Africa.

India ranks 2<sup>nd</sup> next to China in area and production of flowers. The present area is 1.83 lakh hectares and the production is 10.2 million tonnes loose flowers and 66671 lakhs cut flower/annum (Anon., 2010). India covers 15 per cent of area in the world. Almost all the states in India have the tradition of growing flowers. The Commercial production of flowers is presently confined to West Bengal, Karnataka, Tamil Nadu, Andhra Pradesh, Orissa, Gujarath, Uttaranchal, Maharashtra, Uttar Pradesh, New Delhi and Haryana.

Bird-of-paradise (*Strelitzia reginae* Ait.) a newly emerging cut flower, grown in the regions experiencing moderate subtropical climate. The flower got its name from its unusual appearence, which resembles the head of a brightly colored tropical bird. It is also called as crane flower. This slow growing, evergreen perennial is a native of subtropical coasts of southern Africa. It is cultivated on a commercial scale in many parts of the world in order to produce cut flowers for both domestic and international markets. The large scale production of cut bloom is done in California, Hawaii, Israel, France, South Africa and Japan.

Bird-of-paradise occupies a pride place in the garden and it is an important choice for landscaping. In the background of a herbaceous border, in front of a shrubbery or along the side of a tank or lily pool, a highly delightful effect is developed when it is in flowering. It can also be grown in pots and window boxes.

The genus *Strelitzia* belonging to the family Musaceae, includes about five species which are perennial herbaceous evergreen plants. They are *S. augusta*, *S. reginae*, *S. kewensis*, *S. nicoli* and *S. candida*. Out of these *S. reginae* is grown commercially for cut flower production which grows up to a height of 90cm. It is a very popular orange flowered species and is commonly known as bird-of-paradise. The plants are rhizomatous, with erect woody stems and forms clumps of long stalked leaves. Roots are large and strong. The leaf stalk is about 45cm long and the leaf radiate out like a fan. The leaves are grayish green, smooth, and waxy, resembling small banana leaves on longer petioles. The flowers are enclosed in a green, boat-shaped bract edged with red. The vivid flowers grow erectly from the boat like bract, resembling feathers and making this flower look like an exotic bird. Perianth is long exerted and sepals are free, long and carinate. The petals look dissimilar. The stamens are five in number and the ovary is three celled with many seeds.

Cut flowers are living tissues with active metabolism and are subjected to the same basics of ageing and senescence phenomena as that of other parts of the plant. Cut flowers harvested from the plants generally deteriorate much more quickly than those left on the plants, under similar environmental conditions.

It is estimated that about one third of the life of a cut flower is influenced by the pre harvest environment and another two thirds by handling and congenial environment after harvest. Improper handling is considered to be a major cause for post harvest losses of nearly 20-40

per cent of cut flowers. Proper harvesting and post harvest practices or techniques adopted can reduce such post harvest losses.

Both pre and post harvest practices influence the quality and longevity of cut flowers. Though, the quality of a cut flower is mostly a varietal trait, it is greatly influenced by many external factors too.

As most of the cut flowers, unlike most of the agricultural commodities, are harvested before they are fully open, they are expected to continue their growth later, where they are likely to be deprived of metabolites under the conditions in which they are regularly held (Halevy and Mayak, 1974b). This necessitates addition of substances such as sugars, bactericides, growth regulators etc, in the holding solution.

Use of floral preservatives at all stages of handling and marketing of cut flowers is known to maintain the quality of cut flowers and improve the longevity for better consumer preference and satisfaction.

Holding solutions usually contain water to maintain turgidity, sugar as an energy source, a biocide to inhibit the growth of micro organisms, an ethylene inhibitor and an acidifying agent.

Since, bird-of-paradise is becoming increasingly popular as an exquisite flower in India, there is need to standardize the post harvest practices to suit our conditions. Hence, an attempt was made in this direction to find out the “Effect of floral preservatives on quality and vase life of bird-of-paradise (*Strelitzia reginae* Ait.)” with the following objectives.

1. To study the effect of stage of harvest and pulsing solution on the quality and vase life of bird-of-paradise.
2. To study the effect of different floral preservatives and their concentrations in the holding solution, on the quality and vase life of bird-of-paradise.
3. To work out the cost effectiveness of usage of floral preservatives.



*REVIEW OF LITERATURE*

## II. REVIEW OF LITERATURE

Bird-of-paradise (*Strelitzia reginae* Ait.) is a newly emerging cut flower of immense value of the modern world known for its bold effect, through exquisite shape and brilliant colour, attracting vast majority of enthusiastic growers. It is commercially grown in California, Hawaii, Israel, France, South Africa and Japan.

Among the various cut flowers, bird-of-paradise is relatively hardy in nature. The inflorescence is a complex organ composed of morphologically and physiologically different units. The regulatory factors and their inter relationships determine their post harvest longevity and quality. The freshness, as turgidity of flowers in the inflorescence is an important feature which determines the longevity of its flowers.

Out of several ways of extending the post harvest life of cut flowers, the stage of harvest, pulsing, use of chemicals play a major role. Since, the information available on the extension of post harvest longevity of bird-of-paradise cut flowers, is meagre an attempt has been made to present the literature available on stage of harvest, pulsing and use of chemicals on the post harvest behaviour of other cut flowers and the same is presented under the following headings.

2.1 Post harvest physiology of cut flowers.

2.2 Water relations.

2.3 Influence of stage of harvest on vasselife of cut flowers.

2.4 Influence of sucrose as a pulsing agent on post harvest behaviour of cutflowers

2.5 Influence of chemical preservatives on post harvest behaviour of cut flowers.

2.6 Influence of holding solution on post harvest behavior of cut flowers.

2.7 Cost effectiveness of usage of floral preservatives.

### **2.1 Post harvest physiology of cut flowers**

Cut flowers are living, actively metabolizing heterogenous organs , composed of floral and foliar parts each of which may be at different physiological development stage. The termination of vase life of many flowers is characterized by wilting and senescence of petals (Halevy and Mayak, 1979). Once the cut flowers are detached from parent plant they are delinked from the supply of metabolic raw materials. Therefore, exogenous supply of carbohydrates is essential to keep its quality and usefulness of the flower. Water is the first and foremost essential for excised flowers. A source of energy deriving materials for respiration are quite important. A clear understanding of the course of senescence is immensely helpful for establishing techniques to overcome the ageing process.

Carbohydrate supply and maintenance of water balance are the two important factors which plays a vital role in regulating the longevity of cut flowers (Rogers, 1973). Injury at the cut end and presence of microorganisms in the xylem vessel leads to physical blockage thus, altering the regular metabolism by secreting metabolic byproducts causing physiological blockage which could prevent absorption, resulting in severe water deficit (Aarts, 1957). The longevity of cut flowers is shortened by ethylene (Rogers, 1973) because it accelerates the loss of water and decreases the water uptake (Mayak and Diley, 1976) and fresh weight (Nicholos, 1968).

### **2.2 Water relations**

The termination of vase life of many cut flowers is characterized by wilting even though, they are constantly held in water. Many studies

have been made on evaluation of events leading to this phenomenon (Halevy and Mayak, 1981).

After flowers are placed in water they show the changes in fresh weight. Typically the cut flowers show initial increase and subsequently decreasing trend in fresh weight (Rogers, 1973 and Venkatarayappa *et al.*, 1980). Water uptake and water loss show a declining trend till the end of the vase life (Mayak *et al.*, 1974). Decreased rate of water uptake leads to the loss of petal turgidity and fresh weight (Durkin and Kuc, 1966 and Burdett, 1970) which ultimately reduces the vase life of the flowers (Faragher *et al.*, 1986).

Measurement of water uptake and water loss has been determined in most cut flowers (Burdett, 1970; Mayak *et al.*, 1974 and Reddy, 1988). Loss of water from the cut flowers through tissues depends upon external and internal factors. In cut flowers, it was demonstrated that after harvest water loss decreased sharply due to stomatal closure (Mayak *et al.*, 1974) than equal amount of water absorbed (Burdett, 1970; Halevy and Mayak, 1974b) and finally an increase in water loss occurred before wilting (Halevy and Mayak, 1974b). Increase in fresh weight can occur only when the rate of water absorption is greater than the transpiration rate (Rogers, 1973). The cut chrysanthemum flowers when placed in water at 20 degree Celsius (Halevy and Mayak, 1974a), their water balance became negative from the first day of vase life which resulted in disturbed water uptake due to stem blockage. Changes in fresh weight of flowers is correlated with water potential. Initial water balance was higher in sucrose treated rose flowers than that of flowers held in water (Brochov *et al.*, 1976; Bravdo *et al.*, 1974).

Decline in the uptake of water coupled with continuous water loss through transpiration leads to water deficit, which ultimately reduces the turgidity in cut flowers (Halevy and Mayak, 1981). Reduction in water

conductivity seems to be a common process in many cut flowers. Water deficit and water potential relationship of the petals change with age resulting in a lower water holding capacity (Van Meetern, 1979; Acock and Nicholos, 1979). This is caused by many factors, the major factor being vascular blockage, which starts at the cut end moves upward in the stem over a period of time (Marousky, 1972; Sacalis, 1975).

Reduced water transport capacity is directly proportional to the presence of microorganism in the solution (Ford *et al.*,1961) which is due to physical plugging by microorganisms clustered at the cut end or from the accumulation of plugging substances released by microorganisms (Aarts,1957). Enzymatically mediated physiological blockage is atleast partially responsible to cause difficulty in the cut flowers to meet its water requirements for maximum vase life (Burdett, 1970).

Stem plugging by bacteria leads to greater problem in naturally long lived flowers like chrysanthemum (Zagory and Reid, 1986), rose (Weitte *et al.*, 1991), tuberose and gladiolus than in short lived ones. Since, it requires more time for building upon the microbial population. Van Doorn (1997) considered microorganisms as one of the main cause for reduced water uptake by the cut flowers.

### **2.3 Influence of stage of harvest on the vase life of cut flowers**

Kuch and Workman (1964) reported an increase in respiration rate from bud to fully mature condition in carnations. Carnations harvested at tight bud stage and stored at low temperature were in good condition for 18 days (Holley, 1964).

Halevy and Mayak (1974b) and Marousky (1971) demonstrated that some flowers can be harvested as buds and opened in specific chemical solutions. Several possible advantages have been reported for bud opening of flowers.

Harvesting the flowers at mature bud stage reduces the sensitivity of the flowers to extreme temperature, low humidity and ethylene during handling and transport (Nicholos, 1973) but saves the space during shipment (Halevy *et al.*, 1978) and storage (Kofranek, 1976; Marousky, 1971). Harvesting the flowers at bud stage also reduces the hazard of damage to field grown flowers by adverse external conditions like hail storms and temperature as well as incidence of pests and diseases (Halevy and Mayak, 1974b)

Vase life of cut flowers is generally affected by its maturity at harvest (Halevy and Mayak, 1979). Harvesting the flowers before commercial stage of harvest and treating it with appropriate chemical solutions, either before or during storage helps to prolong the vase life and improves the quality of the flowers (Rudnicki *et al.*, 1986)

Carnation harvested at cross bud stage stored well for 20 weeks and the half bloom carnations maintained well up to 28 days only, whereas, open flowers lasted for 15 days (Goszczyńska *et al.*, 1982).

Harvesting gerbera flowers at stage-2 (when ray florets are 3/4<sup>th</sup> opened) and pulsed with 4 per cent sucrose + 250ppm AgNO<sub>3</sub> had highest uptake of water, transpiration loss of water, uptake of water : transpiration loss of water, water balance, fresh weight and vase life (Gopinath, 1996).

Tight and cross bud stage cut flowers of carnation cv. 'Pink Dona' had longer shelf life than cv. 'Design', however, fully opened flowers of both the cultivars were *at par*. The flowers harvested at tight bud stage had longer shelf life than the opened flowers (Sivaprasad, 2002).

The effect of different stages of harvesting *viz.* unopened stage (H<sub>1</sub>) with fully mature buds, 25 per cent opened stage (H<sub>2</sub>) and 50 per cent

opened stage(H<sub>3</sub>) and chemical preservatives at three concentrations *viz.* sucrose(1%, 2% and 3%, sucrose 2% + Al<sub>2</sub>(SO<sub>4</sub>)<sub>3</sub> (0.03%, 0.06% and 0.09%), sucrose 2% + AgNO<sub>3</sub> (0.015%, 0.03% and 0.045%) and sucrose 2% + 8-Hydroxy Quinoline (0.01%, 0.02% and 0.03%) was studied to enhance the post harvest life and quality of golden rod panicles. It was observed that less advanced stages, both unopened and 25%opened stage recorded higher panicle weight, delayed senescence and enhanced vase life along with good quality maintainance. Among the chemical preservatives, sucrose 2 per cent + 8HQS 0.03 per cent showed significantly enhanced floret opening as well as vase life. The treatment combination of unopened stage and 25 per cent opened stage with 2 per cent sucrose + 0.03 per cent 8-Hydroxy Quinoline exhibited excellent flower quality such as excellent flower colour maintainance, turgidity and freshness. Both the treatments showed cent per cent flower opening in panicle, recorded highest useful vase life (Brahmankar *et al.*, 2005).

Singh *et al.* (2005) carried out a study on the effect of harvesting stage, seasonal variation and endogenous carbohydrate level on keeping quality of gladiolus cut flowers. He reported that, the cut flowers of gladiolus harvested at Stage-2 (when 5-7 florets showed colour) had longer vase life compared to the flowers harvested at stage-1(when basal 1-2 florets showed colour). The higher content of reducing sugars at stage-2 has been ascribed to the conversion of starch in to reducing sugars which are necessarily required for the expansion of florets and longer vase life.

Manthur *et al.* (2006) elucidated the effect of stage of harvest and pulsing with sucrose on post-harvest physiology of different stages of cut flowers of gladiolus cv. Vedanapolli. The combination of bud showing colour stage and 20 per cent sucrose pulsing has resulted in maximum uptake of water and favourable water balance. Thus, increasing the fresh

weight and vase life of the flowers by retaining good colour and reducing geotropic bending.

#### **2.4 Influence of sucrose as a pulsing agent on post harvest behaviour of cut flowers**

Sugars, usually used in the form of sucrose, play their role in opening and maintenance of flowers by serving either as an energy source in respiration or as an active substance helping in maintaining the turgidity of the expanding corolla.

Pulsing is found to be of great value in prolonging the vase life, promoting opening and improving the colour and size of petals in many cut flowers. It is a pre-shipment short term treatment practiced by growers or shippers, the effect of which should last for the entire shelf life of the flowers, even when the flowers are held in water (Halevy, 1976; Halevy and Mayak, 1974a, b). The method of pulsing consists of placing the lower portion of flower stems in solution containing sugar and germicides for a period ranging from few hours to as long as two days. It is effective in extending the vase life as well as the quality of cut flowers even when preservatives are not used subsequently at the wholesale or consumer level. The cut flowers may be pulsed with flower preservatives containing sugars, anti-microbial substances and antiethylene substances (Bhattacharjee, 1997). The main ingredient of pulsing solution is however sugar, the percentage of which varies with species and cultivars.

##### **Bird-of-paradise**

The pulsing of cut flower stalk of bird-of-paradise greatly enhanced the longevity and floret opening in both unsorted and stored florets. The best results were obtained by pulsing with 10 per cent sucrose (Halevy *et al.*, 1978). Pulsing the stalks with silver thiosulphate (STS) at 1 mM for

30 minutes to 4 h reduced the longevity of flowers. Pulsing with sucrose at 10 per cent for 24 hours extended the vase life of flowers and increased the number of opened florets. Addition of silver thiosulphate to sucrose pulsing solution did not improve the longevity of flowers compared to sucrose pulsing alone (Finger *et al.*, 1999).

Finger *et al.*, (2003) reported that the inflorescences of bird-of-paradise held in 10 per cent sucrose and 8-HQC at 200 mg $l^{-1}$  with silver nitrate at 10 mg $l^{-1}$  after unpacking had 1.2 times longer postharvest life than the deionised water as control. Packing the flowers in a carton and holding them for 2 days at 22°C did not increase the postharvest life, except when the inflorescence was treated with 5 per cent sucrose before packing. Similarly, by keeping a wet sponge on the stem during the period of packing and keeping in sodium hypochlorite (50 and 100 mg $l^{-1}$ ), 8-HQC at 200 mg $l^{-1}$  or aminooxyacetic acid at 25 ml $l^{-1}$  in the holding solutions did not increase the postharvest life of the flowers. The results obtained suggested that the inflorescences of bird-of-paradise should be harvested when the first floret is just about to emerge from the boat, pulsed with 5 per cent sucrose overnight, then shipped, and upon unpacking, held in 10 per cent sucrose, 8-HQC at 200 mg $l^{-1}$  and silver nitrate at 10 mg $l^{-1}$ .

Pulsing the cut flowers of bird-of-paradise for 48 h with 10 per cent sucrose solution, followed by packing and keeping at 8 °C for 25 days resulted in the highest cumulative uptake of water, the lowest percentage of cumulative physiological loss in weight, maximum number of opened florets per cut flower and longest vase life (Reddy *et al.*, 2005).

## **Roses**

Pulsing ‘Super Star’ roses with 3 per cent sucrose for 18 h at 20° C significantly prolonged the vase life, accelerated the diameter of flowers,

improved the uptake of water and also increased the fresh and dry weights of cut flowers, appreciably, over control (Bhattacharjee, 1998).

De and Bhattacharjee (1998) found that pulsing the cut flowers with sucrose at 6 per cent for different durations, was effective in extending the vase life of rose Cv. Raktagandha. Stems of rose cv. Queen Elizabeth were transferred to vases containing solutions of 1.5 per cent sucrose and 300ppm aluminium sulphate, singly or in combination. Observations on bud opening, vase life and flower size were recorded. The total sugar content of the petals was evaluated after 3 and 6 days. An increased the vase life of flowers to 4.73 days, compared with 3.33 days in the control was observed. Complete opening of the buds was obtained with solutions of sucrose and aluminium sulphate; bud opening was nearly more than 3/4<sup>th</sup> with the other treatments. Solutions containing sucrose and aluminium sulphate resulted in the longest vase life, flower size and sugar content of petals.

### **Tuberose**

The cut flower stalks of *Polyanthus tuberosa*, tended to increase the opening of flowers, when pulsed with sucrose at the rate of 5, 10, 15 or 20 per cent for 2 hour (Gawade *et al.*, 1994).

The vase life of cut flowers of tube rose cv. Double, was increased up to 18 days, compared to 9.8 days in control by treating with sucrose @ 5 per cent for 8h. The treated spikes had the highest percentage of opened florets (Nagaraju *et al.*, 2002).

Effects of sucrose on physiological changes of cut flowers of tuberose after harvest were conducted by pulsing the flower spikes with sucrose (20%) in comparison to control (non-pulsing) flower spikes. All the non-pulsed flower spikes showed higher ethylene production, respiration and shortened vase life compared to the pulsed flower spikes.

Pulsing the flower spikes with sucrose @ 20 per cent increased the bud opening compared to the non pulsed ones. (Jeenbuntug *et al.*, 2007).

Tuberose Flowers were pulsed with sucrose @ 20 per cent only and combined with thidiazuron (TDZ) @ 10, 20 or 50 M for 12 h at 20° C. Distilled water was used as control and pulsed flowers were displayed at 20°C. The results showed that sucrose alone as well as in combination with TDZ significantly increased the percentage of bud opening. Respiration rate of cut flowers pulsed with higher concentrations of TDZ was lower than control treatment. But pulsing had no effect on ethylene production. Therefore, vase life of flowers in all the treatments pulsed with TDZ was higher compared to the flowers pulsed with sucrose @ 20 per cent as well as control (Uthairatanakij *et al.*, 2007).

### **Gladiolus**

Pulsing the cut flowers of gladiolus with 20 per cent sucrose for 16 hours had significantly improved the opening of florets, increased the diameter of floret, uptake of water, longevity of the first floret and vase life and decreased the weight loss of flower spikes in White Enchantress gladiolus (De *et al.*, 1996). A significant improvement in opening of florets was observed in gladiolus cv. 'Psittacinus' pulsed with sucrose @ 2 per cent and this treatment also had shown the highest vase life compared to control (Phanindra, 1996).

Kumar *et al.* (2008) conducted an experiment on gladiolus to determine the effect of pulsing solution for prolonging the vase life of the flowers. Among different treatments, pulsing the cut flowers of gladiolus with sucrose @ 2 per cent , sodium thiosulphate @ 200ppm and GA<sub>3</sub> @ 400ppm recorded highest vase life, size of florets, longevity of floret, number of florets opened at a time, per cent opening of floret and fresh weight of cut flowers.

## **Anthurium**

The cut flowers of anthurium have low sensitivity to ethylene. After treating the cut flowers with different pulsing solutions (Benzyl adenine at 25ppm+ sucrose at 2 %, 8 hydroxy quinoline sulphate, silver thiosulphate & silver nitrate) the spikes were packed in polyethylene bags and were sealed for detecting the ethylene evolution. But ethylene was not detected while analyzing the graphs displayed in gas chromatograph instrument. Hence, it was concluded that ethylene evolved in the flowers due to pulsing treatments was insignificant and also the longevity of anthurium is not affected by ethylene (Akiladevi *et al.*, 2007).

### **2.5 Influence of chemical preservatives on post harvest behaviour of cut flowers**

The use of floral preservatives to preserve the quality and to prolong life of cut flowers has been known for many years. Treatment of flowers with chemical preservatives helps in reducing the rate of respiration and prolonging the vase life of flowers. It also controls growth of bacteria and fungi in the vase solution mainly because of their germicidal property. Several experiments were conducted to study the effect of different chemicals, germicides, sugars, metabolic salts, acidifying agents and hormones on the post harvest longevity of cut flowers having commercial value (Mayak and Dilley, 1976; Abdel-Kader and Rogers, 1986). Certain nontoxic mineral salts notably, aluminium sulphate (Aarts, 1957; Mantur and Nalawadi, 1989), silver nitrate (Halevy *et al.*, 1978),  $\text{CaCl}_2$  (Balakrishna, 1987), cobalt salts (Venkatarayappa *et al.*, 1980), can improve the water balance, thereby extend the longevity of cut flowers. Salts of some metals such as Ag, Co, Ni, Zn, Ca and Al had markedly reduced the ethylene liberation in cut gladiolus stems (Murali, 1990a).

### **2.5.1 Effect of Citric acid**

Citric acid pulse @500ppm proved to be the best in improving uptake of water, maintenance of better water balance, increasing the turgidity and opening of petals there by leading to increase in fresh weight and vase life of the tuberose spikes (Bhaskar *et al.*, 1999).

Cut golden rod flowers treated with citric acid showed the highest vase life, water uptake and better water balance. The best vase solution combination was found to be 2 per cent sucrose with 1mM citric acid (Patil and Reddy, 2001).

Tuberose spikes held in a preservative solution containing 4 per cent sucrose along with 1mM citric acid recorded the maximum water uptake (Padaganur *et al.*, 2004).

Pulsing the cut flowers of rose cv. Queen Elizabeth with 300ppm citric acid and 3 per cent sucrose enhanced the keeping quality of flowers, increased flower diameter, bud size and vase life (Madhubala *et al.*, 2008).

The cut flowers of rose, variety Gladiator kept in vase solution containing D-fructose and citric acid 0.3 per cent each recorded the maximum weight of the cut flowers, diameter of the cut flower and vase life (Nandre *et al.*, 2009).

### **2.5.2 Effect of 8 Hydroxyquinoline sulphate (8-HQS)**

Coorts *et al.* (1965) postulated that 8-HQS had a beneficial effect on the uptake of water by reducing the physiological plugging. They also concluded that 8-HQS was responsible for reducing the transpiration and increasing the fresh weight of cut flowers of rose.

A solution of 200ppm 8-HQS and 1 per cent sucrose increased the longevity of cut flowers of rose by reducing the moisture stress through increased absorption and retention of water. The roses held in this solution lasted twice the duration when held in water (Marousky, 1969).

The cut flowers of chrysanthemum held in a 200ppm 8-HQS +2 per cent sucrose solution showed increased fresh weight, absorbed more solution and developed into larger flowers than those held in water (Marousky, 1972).

Brochat and Donselman (1988) noticed increased vase life of cut flowers of red ginger held in a solution containing 2 per cent sucrose + 200 ppm 8-HQS.

The cut flowers of *Chrysanthemum* cv. Polaris held in a preservative solution containing 200ppm 8-HQS +75ppm citric acid + 5 per cent sucrose recorded greater fresh weight and vase life under refrigeration (7-8°C and 100% relative humidity) than in laboratory condition (25°C and 60% relative humidity) (Arriaga and Guerrero, 1995).

Suneetha and Kumar (1998) recorded the highest vase life, number of florets, floret size and delayed spike bending in cut spikes of gladiolus treated with 5 per cent sucrose + 8HQS 600mg<sup>l</sup><sup>-1</sup>. Improved uptake of water in gladiolus cultivars Sylmia and Friendship was observed when the spikes were held in 400 ppm 8-HQS along with 10 per cent sucrose solution for 20 hours (Shamantakmani *et al.*, 2002).

Pre storage pulsing treatment with 300ppm 8-HQS for 1 hour, followed by 20 per cent sucrose for 12 hour and post storage treatment with vase solution enriched with 300ppm 8-HQS and 5 per cent sucrose significantly improved the flower quality and extended the vase life of gladiolus (Alkasingh *et al.*, 2007).

The cut flowers of rose cv. Gladiator showed minimum chlorosis and bent neck disorder, when flowers treated with sucrose 3 per cent along with 8- HQS @ 200ppm and citric acid @ 300ppm, while the maximum was observed in the control (Dumbre *et al.*, 2002).

Vinodkumar and Bhattacharjee (2004) reported that the D-fructose 3 per cent along with 8-HQS 150ppm pulsing for 24 hours recorded improved post harvest life and quality of Mercedes cut roses over the control.

Reddy *et al.* (2005) reported maximum cumulative transpiration loss of water, lowest cumulative physiological loss in weight and longer vase life in bird-of-paradise cut flower treated with 8-HQS @ 250ppm along with citric acid @ 150ppm. The inflorescence held in 200 mg<sup>l</sup><sup>-1</sup> 8-HQS and 10mg<sup>l</sup><sup>-1</sup> silver nitrate after unpacking had 1.2 times longer post harvest life (Emma Ruth *et al.*, 2008).

Prashanth *et al.* (2007) carried out a study on enhancing the vase life of cut gerbera by addition of floral preservatives. The results indicated that the synergistic effect of 8-HQS and AgNO<sub>3</sub>, as antimicrobial compounds reduced the microbial activity as indicated by lower optical density compared to control, which led to increased water uptake and inturn kept the tissue water potential at higher levels.

Ritujain *et al.* (2007) reported that pulsing of cut rose cv. First red stems with 200ppm 8-HQS + 3 per cent sucrose for 24 hours resulted in maximum vase life, flower diameter, volume of solution consumed, protein and reducing sugar contents in the petal and improved the bloom appearance.

Suhitra *et al.* (2008) studied the effect of different vase solutions on cut flower of gerbera cv. Calcutta orange. Among the different

treatments, 3 per cent sucrose combined with 8-HQS @ 200ppm was found to be better in improving the vase life and relative fresh weight of the flowers.

The effect of 8HQS @ 100, 200 and 300ppm and sucrose @ 5 per cent and 10 per cent treatments on the vase life and post harvest quality of cut flowers of *Strelitzia reginae* Ait. and *Hippeastrum vittatum* Herb. cv. Apple blossom was studied by Hassan (2009). All possible combinations of 8-HQS and sucrose were tested. The treatments were applied as holding solutions, and the cut flowers in control were held in distilled water till the end of the experiment. All the treatments significantly increased the vase life and number of open florets in *Strelitzia reginae* cut flowers compared to control. The treatment of cut flowers of *Hippeastrum vittatum* with 8-HQS and sucrose, improved the vase life and longevity of florets. In addition the percentage of fresh weight gain from the initial weight and the carbohydrate content also enhanced in both the cut flower crops. In order to obtain the highest post harvest quality of cut flowers of *Strelitzia reginae* Ait. and *Hippeastrum vittatum* Herb. cv. Apple blossom, treatment with 8-HQS @ 200ppm + sucrose @10 per cent was recommended.

### **2.5.3 Effect of Silver thiosulphate solution (STS)**

Silver thiosulphate is a very effective chemical used for extending the vase life of many cut flowers, it acts by suppressing ethylene action. STS generally moves faster in to the stem and to corolla (Veen and Geljin, 1978). STS acts as an ethylene antagonist, by reducing the ethylene production and respiration rate (Veen, 1979) of standard carnations.

Reid *et al.* (1980) reported that immersing the cut carnation stems in a solution containing silver thiosulphate, increased the vase life by two folds compared to control. Han and Lee (1992) found that carnation cut

flowers treated with STS at 1mM extended the vase life, minimized fresh weight loss and inhibited ethylene production.

STS complex gets converted in to sulphate anion and is involved in metabolism of flowers and it also prevents the wilting of carnation petals (Veen and Overbeck, 1989). The activity of ethylene producing bacteria can be delayed by pre treating the cut carnation flower with STS (Reid *et al.*,1989).

Li-jen-Lioo *et al.* (2000) reported that the pulse treatment with silver thiosulphate @ 0.2mM for 2 hours extended the vase life of cut rose flowers about 9 to 10 days. Pulsing treatment with STS at 0.5mM for 45 minutes resulted in maximum vase life, maximum gain in fresh and dry weight. Esmaeial *et al.* (2005) reported that pretreatment of First red rose cut flower with 0.5mM silver thiosulphate (STS) solution for 2 hours at 22°C increased the vase life.

Among the different pulsing solutions used for the treatment of gladiolus cut flowers, pulsing the flowers with 20 per cent sucrose along with STS 300ppm and GA<sub>3</sub> 100ppm was found superior. They also reported that the flowers harvested at commercial stage and wet stored under refrigerated condition was found superior on the characters like, maximum days to opening of basal floret, floret size, floret longevity, fresh weight of the spike and vase life (Mukesh *et al.*,2007).

Singh *et al* (2007) studied the effect of different combinations, comprising of sucrose, biocides and ethylene antagonists on keeping quality of standard carnation cv. Taman. The flowers treated with STS 1mM + 5 per cent sucrose + aluminium sulphate 200ppm for 24 hours recorded minimum number of days for bud opening, maximum water uptake and vase life.

#### **2.5.4 Effect of Silver nitrate**

Cut flower of gladiolus treated with silver nitrate 0.01 per cent along with sucrose 4 per cent showed delayed respiration peak and enhanced the vase life by seven days compared to control (Satyavir *et al.*, 1997).

Pulsing cut rose flowers with 4 per cent sucrose or 250 ppm silver nitrate for 24 hours increased the vase life by three days compared to control (Nagarajaiah *et al.*, 2000).

Silver nitrate was found to have adverse effects on fragrance of cut tuberose flowers. The highest water uptake by the spike was found in flowers kept in preservative solution containing  $\text{AgNO}_3$  @ 200ppm (Muhammad *et al.*, 2001)

Shahid (2005) recorded the highest vase life of rose cut flower cv. Whisky Mac and Trika treated with sucrose @25g per litre and 150 ppm  $\text{AgNO}_3$ .

#### **2.5.5 Effect of Aluminium sulphate**

Aluminium sulphate is one among the different bacteriocides that has been experimented commercially to improve the vase life of cut flowers, because of their antimicrobial action.

Schnbal (1976) observed aluminium sulphate as most effective when applied as a foliar spray in reducing transpirational losses thus, improving the longevity of cut rose and carnations. Presence of aluminium in the holding solution reduces transpiration and improves the water balance of cut roses inducing stomatal closure. Aluminium sulphate proved to be effective in bud opening with significant promotion of vase life of roses (Gowda and Langens, 1988).

Aluminium sulphate proved highly effective to obtain higher per cent of full bloomed flowers and there by significantly extending the vase life of cut tuberose (Mukhopadhyay,1982).

Guruprasad *et al.* (2004) reported that ageratum flowers held in chemical solution of 4 per cent sucrose + aluminium sulphate 1.0mM had maximum amount of water uptake, fresh weight and vase life.

The cut flower of rose cv. Happiness held in a solution containing sucrose 1.5 per cent and aluminium sulphate 300ppm recorded the maximum flower diameter , water uptake, fresh weight and vase life compared to control (Karki *et al.*,2004).

Namita *et al.* (2006) reported that the gladiolus cut flowers held in solution four percent sucrose and 400ppm aluminium sulphate recorded the maximum floret diameter, floret longevity, floret opening, water uptake and vase life.

Madhubala *et al.* (2008) noted that among the different chemicals tested, cut flowers of rose held in 1.5 per cent sucrose and 300ppm aluminium sulphate was found to be best for bud opening, flower diameter, bud size, water uptake and vase life.

Aluminium sulphate @ 500ppm +sucrose @ 4 per cent were found to be best to obtain longest vase life, maximum uptake of water, highest fresh weight of tuberose spikes as well as lowest percentage of physiological loss in weight. Whereas, 8-HQS @400 ppm + sucrose @ 4 per cent was observed to be the best for the highest percentage of opened flowers and florets and lowest percentage of neck bent florets (Varu and Barad, 2008).

### **2.5.6 Effect of Sodium hypochlorite**

Sodium hypochlorite is considered to be an effective biocide for increased water uptake, maintenance of fresh weight and for extending storage life of cut chrysanthemum (Kofranek, 1992).

Chrysanthemum is very sensitive to high temperature which will shorten its vase life by lowering the carbohydrate concentration. Presence of bacteria in tap water can also cause wilting of chrysanthemum and flower bud fail to open. An investigation was therefore carried out to study the effect of cold water, sodium hypochlorite (NaOCl) and glucose on the vase life of chrysanthemum cut flowers and their freshness under ambient temperature ( $25^{\circ} \pm 1^{\circ}\text{C}$ ). Chrysanthemum cut flowers were kept in tap water, cold water ( $4^{\circ} \pm 1^{\circ}\text{C}$ ), 0.5% NaOCl, 1.0% NaOCl, 5.0% NaOCl, 5% glucose, 10% glucose and 15% glucose. All the treatments were found to have positive effect on the flower diameter and blooming rate compared to tap water treatment (Koon, 2009).

### **2.6 Influence of holding solution on post harvest behaviour of cut flowers of bird-of-paradise**

The bird-of-paradise inflorescences held in 10 per cent sucrose and 8-HQC @200mg L<sup>-1</sup> with silver nitrate @10 mgL<sup>-1</sup> after unpacking had 1.2 times longer post harvest life than the flower kept in deionised water. Packing in a carton and holding for 2 days at 22°C did not increase the post harvest life, except when the inflorescences were treated with sucrose @ 5 per cent before packing. The results obtained suggested that bird-of-paradise inflorescences should be harvested when the first floret was just about to emerge from the boat, pulsed with sucrose @ 5 per cent overnight then shipped and upon unpacking held in sucrose @10 per cent, 8-HQC @ 200mgL<sup>-1</sup> and silver nitrate @10mgL<sup>-1</sup> (Bayogan *et al.*, 2008).

## **Rose**

The cut flowers of rose cv. Gladiator held in a vase solution containing 5 per cent sucrose, 300ppm citric acid and 300ppm aluminium sulphate showed the longest vase life (Patil and Singh, 1995).

Longest vase life, lowest percentage of wilting of petals, highest uptake of water and largest diameter of flower were recorded in holding solution involving sucrose, aluminum sulphate and 8-HQC in respect of cut flowers of rose cv. Happiness. The rose cut flowers packed in cellophane sheets for 24 hours exhibited longest vase life, lowest percentage of wilting of petals, largest diameter of flower and highest uptake of water (Jothi and Moorthy, 1999).

The holding solution containing sucrose and 8-HQC was proved to be beneficial for the earliest opening and longest vase life of cut flowers of rose cv. Prime Beauty (Maitra *et al.*, 2001).

A comparative study of holding solutions containing 30mg<sup>l</sup><sup>-1</sup> sodium dichloroisocyanurate (DICA), 250mg<sup>l</sup><sup>-1</sup> 8HQS and 150mg<sup>l</sup><sup>-1</sup> Physan-20 together with 5 per cent sucrose to improve vase life of Red local, Orange sky, Pinky show and Yellow Queen cut miniature roses was carried out at room temperature. Vase life of 'Red local' and 'Orange sky' cut roses improved most in the solution containing 8-HQS and sucrose, while 'Pinky show' and 'Yellow Queen' cut roses were maintained longer in solution containing DICA + sucrose compared to tap water. Either one or both of these two holding solutions increased the uptake of solution and fresh weight and decreased the bent neck of cut roses compared to tap water (Ketsa and Chinprayoon, 2005).

Eight rose cultivars (Janter Manter, Imperator, Lahar, Pandit Nehru, Sugandha, Arjun, Kentucky Durbey and Fetura) were collected from field grown plants at the bud stage and were maintained in holding

solution containing different preservatives (sucrose, thiourea, citric acid, aluminium sulphate, calcium nitrate and silver thiosulphate, singly or in combination). Aluminium sulphate (300 ppm) and sucrose 3 per cent and aluminium sulphate alone were found to be most effective in the improvement of the post harvest quality of cut roses (Gupta *et al.*, 2007).

### **Anthurium**

The effect of holding solution containing benzyladenine in combination with sucrose and 8-HQS on the post harvest life of cut flowers of anthurium cultivars like Red, Merengue and Casino were studied in terms of fresh weight, water relations, initiation of termination symptoms and total vase life. Cultivar Live Red exhibited higher vase life with the treatment of Benzyladenine @ 10 ppm in combination with sucrose @ 4 per cent and 8 HQS @ 200 ppm over control. Merengue and Casino recorded higher vase life upon treatment with 15ppm benzyladenine + sucrose @4 per cent + 8-HQS @ 200ppm (Anuradha *et al.*, 2002).

### **Gladiolus**

The effect of vase solution containing 4 per cent sucrose and 400 ppm aluminium sulphate, singly or in combination on the post harvest quality of gladiolus cv. White prosperity were studied. The vase life of spikes was highest in solution containing sucrose and aluminium sulphate compared to control as well as in solution containing sucrose and aluminum sulphate alone (Singh *et al.*, 2004).

### **Tuberose**

Gargi *et al.* (2005) investigated the effect of different holding solutions on the quality and vase life of tuberose cv. Single. Among the different vase solutions, silver nitrate proved to be the best for improving the quality and lengthening of the life of cut tuberose. Aluminium

sulphate was also found good for improving the post harvest life of the cut flower spikes.

Bharathi and Usha (2009) recommended Calcium chloride @ 1 per cent, sucrose @ 4 per cent and 8-HQC @ 200ppm as the vase solution for increasing the shelf life of tuberose cut flowers.

### **Carnation**

Bhatia *et al.* (2002) obtained increased diameter of flowers and reduced fresh weight loss in cut carnation cultivar Impala and Purple Choppin (spray), which were held in a holding solution containing 100ppm 8HQC and 2 per cent sucrose.

### **2.7 Cost effectiveness of usage of floral preservatives**

Highest ratio of vase life to total cost was obtained by Varadaraju (2010) when the cut flowers of heliconia were stored at 20°C for two days and pulsed with sucrose @ 10 per cent for 48 hours + 200ppm 8HQS + 150ppm citric acid while, the lowest ratio was obtained in the flowers stored at 20°C for three days and pulsed with sucrose @ 10 per cent for 48 hours + 200ppm 8HQS + 150ppm citric acid.



*MATERIAL AND METHODS*

### **III. MATERIAL AND METHODS**

The present investigation entitled "Effect of floral preservatives on quality and vase life of Bird of Paradise (*Strelitzia reginae* Ait.)" was carried out during November 2010 to January 2011 at the Department of Horticulture, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bengaluru. The details of location, the materials used and the techniques adopted during the period of experimentation are presented below.

#### **3.1 Location**

The experiments were conducted under laboratory conditions in the Department of Horticulture, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bengaluru. The temperature and relative humidity recorded during the period of experimentation are presented in Appendix I.

#### **3.2 Materials used**

##### **3.2.1 Plant material**

The cut flowers of Bird of Paradise used in the present studies were procured from Ashwath Farm, Doddaballapur situated at about 40 km away from the Department of Horticulture, Gandhi Krishi Vignana Kendra, University of Agricultural Sciences, Bengaluru. The flowers were harvested at three different stages i.e., two days before commercial stage of harvest, commercial stage of harvest(one floret opened stage) and two days after commercial stage of harvest(two floret open stage). Immediately after harvest, the basal portions of the cut flowers were immersed in a bucket containing 6" tap water and were brought to the laboratory for imposing the treatments.

### **3.2.1.1 Description of the cultivar**

The cut flowers of the bird-of-paradise cv. Humilis were selected for the experiment. The flowers of this variety are orange and purple and very brilliant in colour, emerging from the purplish spathes on a stem. The plants of this variety grow up to a height of 0.9-1.2 m at a temperature range of 20-22°C. The peak period of flowering in this variety is from October to December.

### **3.2.2 Chemical preservatives**

1	Sucrose	(C <sub>12</sub> H <sub>22</sub> O <sub>11</sub> )
2	8-Hydroxy Quinoline Sulphate	(8-HQS)
3	Citric Acid	(C <sub>6</sub> H <sub>8</sub> O <sub>7</sub> )
4	Silver nitrate	(AgNO <sub>3</sub> )
5	Aluminium sulphate	(Al <sub>2</sub> SO <sub>4</sub> )
6	Sodium hypochlorite	(NaOCl)
7	Silver thiosulphate	(Ag <sub>2</sub> H <sub>2</sub> O <sub>3</sub> S <sub>2</sub> )

## **3.3 Methodology**

### **3.3.1 Preparation of chemical preservative solutions**

#### **3.3.1.1 Preparation of chemical preservative solutions for Experiment I**

Stock solutions of required chemicals for experiment-1 were prepared as stated below.

1. Stock solution of sucrose 85 per cent strength was prepared by dissolving 850g of sucrose in 1 litre distilled water.
2. The stock solution of citric acid 2000ppm strength was prepared by dissolving 2g of citric acid in 1 litre distilled water.

3. 8-Hydroxy Quinoline Sulphate (8HQS) of 3000 ppm strength was prepared by dissolving 3g of 8-Hydroxy Quinoline Sulphate in 1 litre of distilled water.

From the above stock solutions, 300ml pulsing solutions were prepared as shown in the following table.

Serial no.	Concentration of chemical in 300ml pulsing solution	Quantity of particular stock solution used
1	5% sucrose	17.65ml
2	10% sucrose	35.3ml
3	15% sucrose	52.94ml
4	150ppm citric acid	22.5ml
5	200ppm 8-HydroxyQuinolineSulphate	20ml

The required quantity of the stock solution of different preservative chemicals are pipetted out in to the measuring flask , then the volume is made up to 300ml by using distilled water and then they were poured in to the conical flasks of 500ml volume.

### **3.3.1.2 Preparation of chemical preservative solutions for Experiment II**

Stock solutions of the required chemicals for the experiment-2 were prepared as follows;

1. The stock solution of 60 per cent sucrose was prepared by dissolving 600g of sucrose in 1 litre distilled water.
2. Citric acid stock solution (3000 ppm) was prepared by dissolving 3g of citric acid in 1 litre distilled water.

3. 8-Hydroxy Quinoline Sulphate (8HQS) of 1000 ppm strength was prepared by dissolving 1g of 8-Hydroxy Quinoline Sulphate in 1 litre of distilled water.
4. Silver nitrate stock solution of 500 ppm strength was prepared by dissolving 0.25g in 500ml distilled water.
5. The stock solution of 2000 ppm aluminium sulphate was prepared by dissolving 2g in 1litre distilled water.
6. Sodium hypochlorite stock solution of 500 ppm concentration was prepared by dissolving 0.5g in 1 litre distilled water.
7. Preparation of Silver thiosulphate solution - The Silver thiosulphate solution was prepared with a molar ratio between silver nitrate and sodium thiosulphate of 1:4, respectively. Both the prepared solution were added simultaneously and mixed well before use.

Sodium thiosulphate solution was prepared by dissolving 1.44g sodium thiosulphate in 300ml distilled water and silver nitrate solution was prepared by dissolving 0.65g silver nitrate in 100ml distilled water.

The stock solution of silver thiosulphate stock of 2000 ppm concentration was prepared by simultaneous mixing of 50ml prepared silver nitrate solution with 50ml sodium thiosulphate solution.

The holding solutions of 300ml were prepared by using these stock solutions as indicated below,

Serial no.	Concentration of chemical in 300ml holding solution	Quantity of particular stock solution used.
1	5% sucrose	25ml
2	10% sucrose	50ml
3	100ppm silver thiosulphate	15ml
4	150ppm citric acid	15ml
5	25ppm silver nitrate	15ml
6	50ppm silver nitrate	30ml
7	300ppm aluminium sulphate	45ml
8	400ppm aluminium sulphate	60ml
9	50ppm sodium hypochlorite	30ml
10	100ppm sodium hypochlorite	60ml
11	200ppm 8-Hydroxy QuinolineSulphate	60ml
12	250ppm 8-Hydroxy QuinolineSulphate	75ml

The stock solution of required quantity were pipetted out in to the measuring flask and volume was made up to 300ml by using distilled water and then the solutions were poured in to the conical flask of 500ml capacity.

### **3.3.2 Preparation of cut flowers for the experiments**

The preconditioned spikes of uniform size were selected, so as to maintain uniformity within the replications. The basal portion of the flower spikes were cut again under water and a uniform stem length of 60 cm was maintained.

### **3.4 Details of the experiments**

#### **3.4.1 Experiment-I: Evaluation of the best stage of harvest and pulsing solution on the vase life of bird-of-paradise (*Strelitzia reginae* Ait.)**

Experimental design	: Factorial Completely Randomized Design (FCRD)
Number of treatments	: 12 (Twelve)
Number of replications	: 3(Three)
Number of cut flowers/ replication	: 1(One)
Number of cut flowers/treatment	: 3(Three)

#### **Treatment details**

##### **Main treatments : Stage of Harvest**

- S<sub>1</sub> : Harvesting the cut flower at two days before commercial stage of harvest
- S<sub>2</sub> : Harvesting the cut flower at commercial stage of harvest (one floret open stage)
- S<sub>3</sub> : Harvesting the cut flower at two days after commercial stage of harvest

##### **Sub treatments : Pulsing solutions**

- P<sub>0</sub> : Distilled water
- P<sub>1</sub> : 5% Sucrose + 200ppm 8HQS + 150ppm Citric acid
- P<sub>2</sub> : 10% Sucrose + 200ppm 8HQS + 150ppm Citric acid
- P<sub>3</sub> : 15% Sucrose + 200ppm 8HQS + 150ppm Citric acid

##### **Treatments combinations:**

- T<sub>1</sub>: Harvesting the flower at two days before commercial stage of harvest +pulsing with distilled water (Control)



**Harvested two days prior to commercial stage of harvest**



**Harvested at commercial stage of harvest (one floret open stage)**



**Harvested two days after commercial stage of harvest**

**Plate 1: Bird-of-paradise flowers harvested at different stages**

- T<sub>2</sub>: Harvesting the flower at two days before commercial stage of harvest + pulsing with 5% Sucrose + 200ppm 8HQS + 150ppm Citric acid
- T<sub>3</sub>: Harvesting the flower at two days before commercial stage of harvest + pulsing with 10% Sucrose + 200ppm 8HQS + 150ppm Citric acid
- T<sub>4</sub>: Harvesting the flower at two days before commercial stage of harvest + pulsing with 15% Sucrose + 200ppm 8HQS + 150ppm Citric acid
- T<sub>5</sub>: Harvesting the flower at commercial stage of harvest + pulsing with distilled water (Control)
- T<sub>6</sub>: Harvesting the flower at commercial stage of harvest + pulsing with 5% Sucrose + 200ppm 8HQS + 150ppm Citric acid.
- T<sub>7</sub>: Harvesting the flower at commercial stage of harvest + pulsing with 10% Sucrose + 200ppm 8HQS + 150ppm Citric acid
- T<sub>8</sub>: Harvesting the flower at commercial stage of harvest + pulsing with 15% Sucrose + 200ppm 8HQS + 150ppm Citric acid
- T<sub>9</sub>: Harvesting the flower at two days after commercial stage of harvest + pulsing with Distilled water (Control)
- T<sub>10</sub>: Harvesting the flower at two days after commercial stage of harvest+ pulsing with 5% Sucrose + 200ppm 8HQS + 150ppm Citric acid
- T<sub>11</sub>: Harvesting the flower at two days after commercial stage of harvest+ pulsing with 10% Sucrose + 200ppm 8HQS + 150ppm Citric acid
- T<sub>12</sub>: Harvesting the flower at two days after commercial stage of harvest + pulsing with 15% Sucrose + 200ppm 8HQS + 150ppm Citric acid

The cut flowers were placed individually in a 500 ml bottle containing 300 ml pulsing solution or distilled water according to the treatment specified. After 48 hours, the flowers were transferred in to the bottles containing 300ml distilled water until the end of its vase life.

**3.4.2 Experiment-II: Effect of floral preservatives and their concentration in the holding solution on the quality and vase life of bird-of-paradise harvested at commercial stage of harvest**

Experimental design : Completely Randomized Design (CRD)  
Number of treatments : 17(seventeen)  
Number of replications : 3(Three)  
Number of cut flower/ replication : 1(One)  
Number of cut flower/treatment : 3(Three)

**Treatment details:**

- T<sub>1</sub>: Distilled water ( Control )
- T<sub>2</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 25ppm
- T<sub>3</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 50ppm
- T<sub>4</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 300ppm
- T<sub>5</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 400ppm
- T<sub>6</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 50ppm
- T<sub>7</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 100ppm
- T<sub>8</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + 8-Hydroxy Quinoline Sulphate 200ppm
- T<sub>9</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + 8-Hydroxy Quinoline Sulphate 250ppm

- T<sub>10</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 25ppm
- T<sub>11</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 50ppm
- T<sub>12</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 300ppm
- T<sub>13</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 400ppm
- T<sub>14</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 50ppm
- T<sub>15</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 100ppm
- T<sub>16</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + 8-Hydroxy Quinoline Sulphate 200ppm
- T<sub>17</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + 8-Hydroxy Quinoline Sulphate 250ppm

The cut flowers were placed individually in a 500 ml bottle containing 300 ml holding solutions, as per the treatment specified, until the end of their vase life.

### **3.5 OBSERVATIONS RECORDED**

The following Observations were recorded on daily basis for both Experiment I and Experiment II.

#### **3.5.1 Uptake of water**

The uptake of water from the cut flower spike was obtained by the difference between the consecutive weights of the bottle with the

preservative solution (without flowers), and it is expressed in gram/cut flower for that period.

$$\text{Water uptake} = [B+S]_{\text{Day1}} - [B+S]_{\text{Day2}}$$

B – Weight of the bottle, S – Weight of the solution

### **3.5.2 Loss of water**

The loss of water from the cut flower was obtained by the difference between the consecutive weights of the bottle with preservative solution and flower spike, and it is expressed in gram/cut flower for that period.

$$\text{Water loss} = [B+S+F]_{\text{Day1}} - [B+S+F]_{\text{Day2}}$$

B – Weight of the bottle, S – Weight of the solution, F- Weight of the cut flower

### **3.5.3 Uptake of water: Loss of water**

It is obtained by computing the ratio between uptake of water and loss of water from the cut flower.

$$\text{Water uptake} : \text{Water loss} = \text{Water uptake} / \text{Water loss}$$

### **3.5.4 Water balance**

The water balance of the cut flower was determined by the difference between the uptake of water and the loss of water from that cut flower. It is expressed in gram/cut flower for that period.

$$\text{Water balance} = \text{Water uptake} - \text{Water loss}$$

### **3.6.5 Fresh weight of cut flowers (g)**

The fresh weight of the cut flower was obtained by the difference between the weight of bottle plus solution plus cut flower and the weight of bottle plus solution on the particular day and it is expressed in grams.

$$\text{Fresh weight of the cut flower (FW)} = [B+S+F] - [B+S]$$

B – Weight of the bottle, S – Weight of the solution, F - Weight of the cut flower

### **3.6.6 Physiological loss in weight of cut flowers (%)**

The physiological loss in weight of the cut flower was obtained by the difference between the consecutive fresh weights of cut flowers and it is expressed in percentage.

$$\text{Physiological loss in weight (PLW)} = \{[(FW)_{\text{Day1}} - (FW)_{\text{Day2}}] / (FW)_{\text{Day1}}\} \times 100$$

FW= Fresh weight of the flower spike

### **3.6.7 Vase life of cut flowers (days)**

The vase life of the cut flower was determined by counting the number of days starting from the day of harvest to the day before the wilting of last floret. It is expressed in days.

## **3.7 Statistical analysis**

The data collected from experiment 1 and 2 were subjected to statistical analysis by using Factorial Completely Randomized Design and Completely Randomized Design, respectively, as outlined by Panse and Sukhatme (1978). The results were tested at 5 per cent level of significance.

## **3.8 Cost effectiveness of usage of floral preservatives**

Cost effectiveness of floral preservatives used in the best experiment in relation to the vase life of bird-of-paradise cut flowers were worked out on the basis of additional vase life to additional cost ratio.



*EXPERIMENTAL RESULTS*

## **IV. EXPERIMENTAL RESULTS**

Investigation on the “Effect of floral preservatives on quality and vase life of bird-of-paradise (*Strelitzia reginae* Ait)” were carried out at the Department of Horticulture, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru during November, 2010 – January, 2011. The results obtained are presented here under.

### **4.1 Experiment-I: Evaluation of the best stage of harvest and pulsing solution on the vase life of bird-of-paradise**

#### **4.1.1 Water relations**

The results on the water relation *viz.*, uptake of water, transpiration loss of water, ratio of water uptake and water loss and water balance pertaining to the cut flowers of bird-of-paradise as influenced by the stage of harvest and pulsing solutions are presented below.

##### **4.1.1.1 Uptake of water (g/cut flower)**

The data pertaining to the uptake of water as effected by stages of harvest and pulsing solutions are presented in Table1 and Figure1.

Both the uptake of water and cumulative uptake of water differed significantly between different stages of harvest, pulsing solution and their interactions.

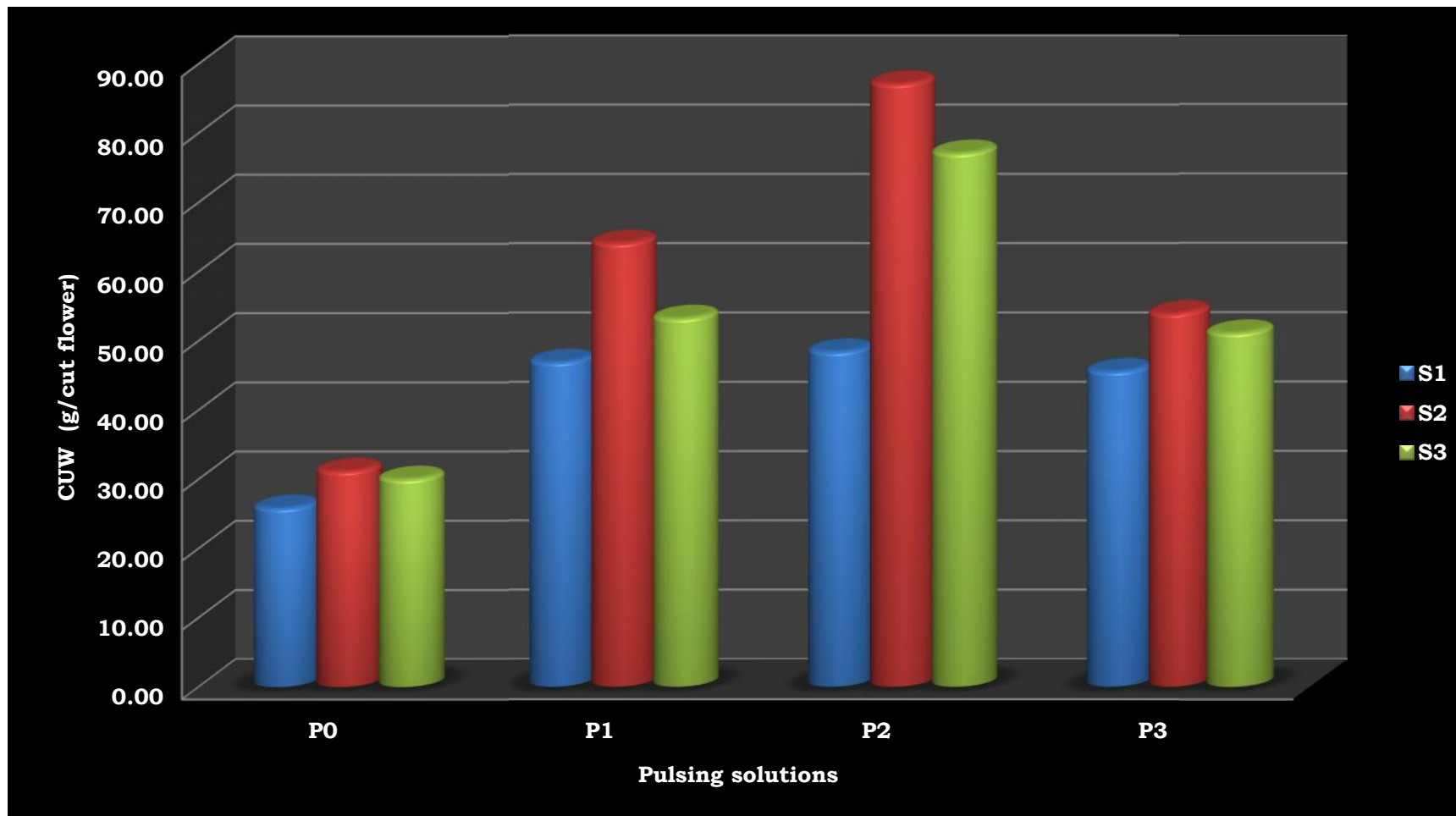
The uptake of water was found highest in the flowers harvested at commercial stage of harvest (S<sub>2</sub>) during the intervals D<sub>1</sub> (uptake of water of day 1-4), D<sub>2</sub>(uptake of water of day 5-8), D<sub>3</sub> (uptake of water of day 9-12) and D<sub>4</sub> (uptake of water of day 13-16) (19.92, 15.04, 13.08 and 10.96 g/cut flower, respectively) whereas, the lowest water uptake was

**Table 1: Uptake of water by bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions**

Uptake of water(UW) (g/cut flower)												
Days	<b>D<sub>1</sub></b> (UW of day 1-4)				<b>D<sub>2</sub></b> (UW of day 5-8)				<b>D<sub>3</sub></b> (UW of day 9-12)			
Treatments/Stage	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN
P <sub>0</sub>	9.50	11.33	11.17	10.67	6.50	7.67	7.17	7.11	6.33	6.67	6.67	6.56
P <sub>1</sub>	16.33	23.00	19.00	19.44	11.83	16.67	12.17	13.56	10.17	13.33	11.83	11.78
P <sub>2</sub>	18.17	28.50	25.33	24.00	13.33	22.67	19.33	18.44	10.50	19.17	17.83	15.83
P <sub>3</sub>	15.50	16.83	16.33	16.22	11.67	13.17	12.50	12.44	9.83	13.17	12.17	11.72
MEAN	14.88	19.92	17.96		10.83	15.04	12.79		9.21	13.08	12.13	
	S	T	S×T		S	T	S×T		S	T	S×T	
F test	*	*	*		*	*	*		*	*	*	
SEm±	0.18	0.21	0.37		0.14	0.16	0.28		0.16	0.18	0.32	
CD@5%	0.53	0.62	1.07		0.41	0.47	0.82		0.47	0.54	0.93	

Days	<b>D<sub>4</sub></b> (UW of day 13-16)				<b>CUW</b> (Cumulative UW)			
Treatments/Stage	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN
P <sub>0</sub>	3.50	5.50	5.00	4.67	25.83	31.17	30.00	29.00
P <sub>1</sub>	8.50	11.00	10.17	9.89	46.83	64.00	53.17	54.67
P <sub>2</sub>	6.33	16.67	14.50	12.50	48.33	87.00	77.00	70.78
P <sub>3</sub>	8.50	10.67	10.00	9.72	45.50	53.83	51.00	50.11
MEAN	6.71	10.96	9.92		41.63	59.00	52.79	
	S	T	S×T		S	T	S×T	
F test	*	*	*		*	*	*	
SEm±	0.13	0.15	0.25		0.34	0.40	0.69	
CD@5%	0.37	0.43	0.74		1.00	1.16	2.01	

**S<sub>1</sub>** : Harvesting the flower at two days before commercial stage of harvest, **S<sub>2</sub>** : Harvesting the flower at commercial stage of harvest, **S<sub>3</sub>** : Harvesting the flower at two days after commercial stage of harvest. **P<sub>0</sub>** : No pulsing (Kept in distilled water), **P<sub>1</sub>** : Pulsing with 5 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours, **P<sub>2</sub>** : Pulsing with 10 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours, **P<sub>3</sub>** : Pulsing with 15 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours



**Figure 1: Cumulative uptake of water (CUW) by bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions**

observed in flowers harvested two days prior to commercial stage of harvest ( $S_1$ ) during the same intervals (14.88, 10.83, 9.21 and 6.71 g/cut flower, respectively). The cumulative uptake of water was also registered highest in flowers harvested at  $S_2$  (59.00g/cut flower) and lowest in  $S_1$  (41.63 g/cut flower).

The results revealed that the flowers pulsed with  $P_2$ (10% sucrose + 200ppm 8HQS + 150ppm citric acid for 48 hours) had significantly higher uptake of water during the intervals  $D_1$ ,  $D_2$ ,  $D_3$  and  $D_4$  (24.00, 18.44, 15.83 and 12.50 g/cut flower, respectively). While,  $P_0$  (no pulsing) recorded the lowest water uptake during the same intervals(10.67, 7.11, 6.56 and 4.67 g/cut flower, respectively). Similarly the cumulative uptake of water was found significantly highest in  $P_2$  (70.78 g/cut flower) and lowest in  $P_0$  (29.00 g/ cut flower).

The interaction effect of stages of harvest and pulsing treatments was found to be highest in  $S_2P_2$  (cut flowers harvested at commercial stage and pulsed with 10% sucrose + 200ppm 8HQS + 150ppm citric acid for 48 hours)during the interval  $D_1$ ,  $D_2$ ,  $D_3$  and  $D_4$  (28.50, 22.67, 19.17 and 16.67 g/cut flower, respectively). The lowest water uptake was found with interaction of  $S_1P_0$  (cut flowers harvested two days before commercial stage and no pulsing) during the same interval (9.50, 6.50, 6.33 and 3.50 g/cut flower, respectively). The cumulative uptake of water was also found to be significantly highest with the interaction  $S_2P_2$  (87.00 g/cut flower) and the lowest was found in  $S_1P_0$  (25.83 g/cut flower).

#### **4.1.1.2 Loss of water (g/cut flower)**

The data relating to the loss of water as influenced by stages of harvest and pulsing solutions in bird-of-paradise cut flower are presented in Table 2 and depicted in Figure 2.

Both the loss of water and cumulative loss of water differed significantly between different stages of harvest, pulsing solution and their interactions.

The results revealed that the bird-of-paradise cut flower harvested at commercial stage of harvest ( $S_2$ ) had higher loss of water during the intervals  $D_1$ ,  $D_2$ ,  $D_3$  and  $D_4$  (21.50, 16.55, 14.49 and 11.85 g/cut flower, respectively) and the lowest was seen in flowers harvested two days prior to commercial stage of harvest ( $S_1$ ) during the same intervals (17.71, 13.21, 11.20 and 7.84 g/cut flower, respectively). The cumulative loss of water was also highest in flowers harvested at  $S_2$  (64.39 g/cut flower) and lowest in flowers harvested at  $S_1$  (49.96 g/cut flower).

The loss of water as influenced by the pulsing solution registered the highest value in flowers pulsed with 10 per cent sucrose + 200ppm 8HQS + 150ppm citric acid for 48 hours ( $P_2$ ) during the intervals  $D_1$ ,  $D_2$ ,  $D_3$  and  $D_4$  (25.67, 20.10, 16.61 and 13.24 g/cut flower, respectively). Whereas, the lowest was recorded in the flowers held in distilled water without pulsing ( $P_0$ ) during the same intervals (13.17, 9.41, 8.89 and 6.02 g/cut flower, respectively). Similarly the cumulative loss of water was highest in flowers pulsed with  $P_2$  (75.62 g/cut flower) and lowest in flowers without pulsing  $P_0$  (37.49 g/cut flower).

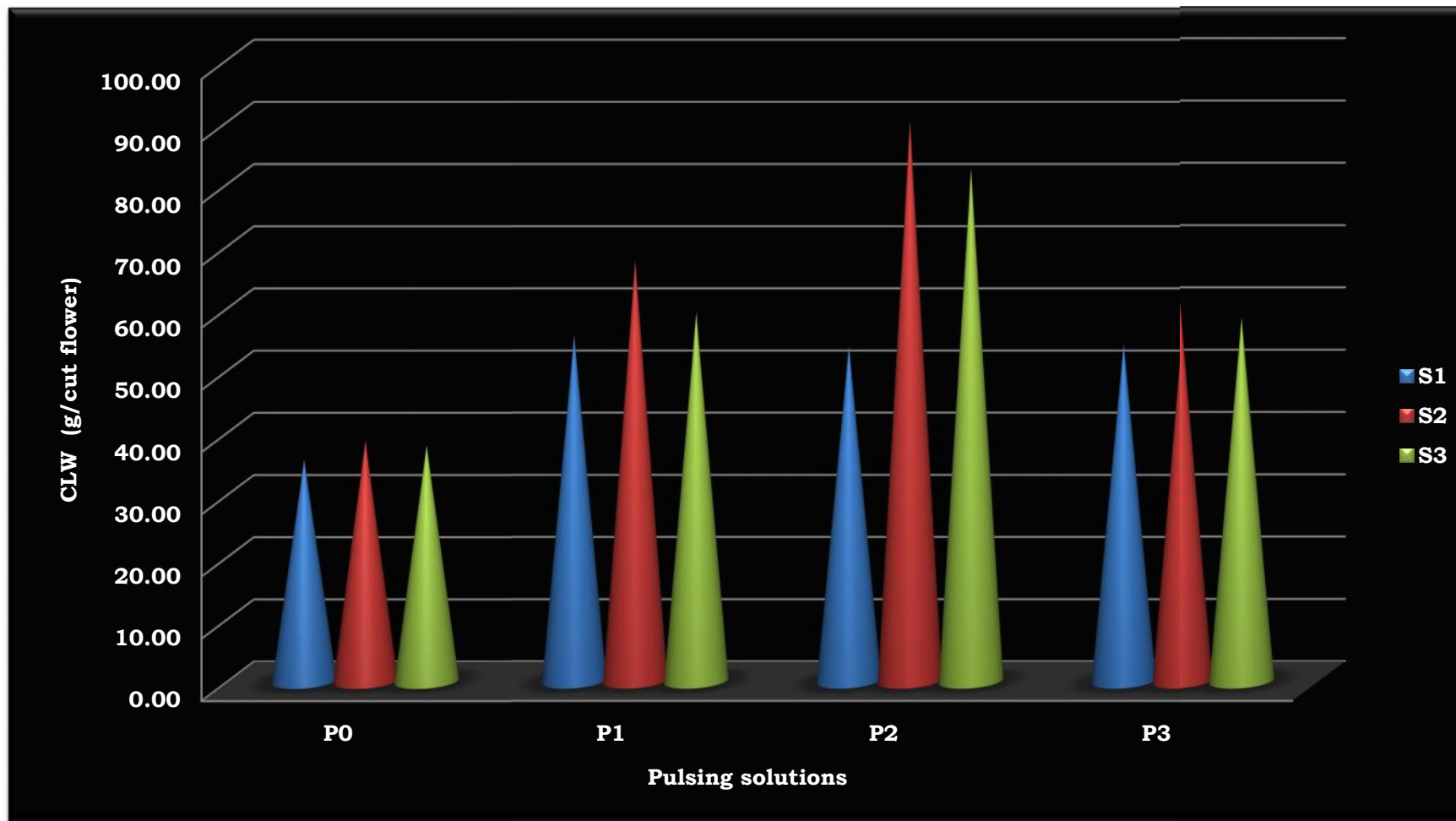
The interaction effect of stages of harvest and pulsing treatments recorded the maximum value in  $S_2P_2$  (cut flowers harvested at commercial stage and pulsed with 10% sucrose + 200ppm 8HQS + 150ppm citric acid for 48 hours) during the interval  $D_1$ ,  $D_2$ ,  $D_3$  and  $D_4$  (29.50, 23.63, 19.80 and 17.30 g/cut flower, respectively) and the lowest was recorded with the interaction of  $S_1P_0$  (cut flowers harvested two days before commercial stage and no pulsing) during the same interval (12.67, 9.07, 8.90 and 5.07 g/cut flower, respectively). The cumulative loss of

**Table 2: Loss of water by bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions**

Transpiration loss of water(TLW)(g/cut flower)												
Days	<b>D<sub>1</sub></b> (TLW of day 1-4)				<b>D<sub>2</sub></b> (TLW of day 5-8)				<b>D<sub>3</sub></b> (TLW of day 9-12)			
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN
P <sub>0</sub>	12.67	13.50	13.33	13.17	9.07	9.83	9.33	9.41	8.90	8.83	8.93	8.89
P <sub>1</sub>	19.33	24.17	21.00	21.50	14.43	17.57	14.33	15.44	12.33	14.17	12.83	13.11
P <sub>2</sub>	20.17	29.50	27.33	25.67	15.33	23.63	21.33	20.10	11.40	19.80	18.63	16.61
P <sub>3</sub>	18.67	18.83	18.50	18.67	14.00	15.17	14.67	14.61	12.17	15.17	14.17	13.83
MEAN	17.71	21.50	20.04		13.21	16.55	14.92		11.20	14.49	13.64	
	S	T	S×T		S	T	S×T		S	T	S×T	
F test	*	*	*		*	*	*		*	*	*	
SEm±	0.21	0.24	0.41		0.15	0.18	0.31		0.17	0.20	0.34	
CD@5%	0.60	0.70	1.21		0.45	0.52	0.90		0.49	0.57	0.99	

Days	<b>D<sub>4</sub></b> (TLW of day 13-16)				<b>CLW</b> (Cumulative TLW)			
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN
P <sub>0</sub>	5.07	6.60	6.40	6.02	35.70	38.77	38.00	37.49
P <sub>1</sub>	9.67	11.83	11.17	10.89	55.77	67.73	59.33	60.94
P <sub>2</sub>	7.13	17.30	15.30	13.24	54.03	90.23	82.60	75.62
P <sub>3</sub>	9.50	11.67	11.00	10.72	54.33	60.83	58.33	57.83
MEAN	7.84	11.85	10.97		49.96	64.39	59.57	
	S	T	S×T		S	T	S×T	
F test	*	*	*		*	*	*	
SEm±	0.13	0.15	0.26		0.40	0.46	0.79	
CD@5%	0.38	0.44	0.76		1.15	1.33	2.31	

**S<sub>1</sub>** : Harvesting the flower at two days before commercial stage of harvest, **S<sub>2</sub>** : Harvesting the flower at commercial stage of harvest, **S<sub>3</sub>** : Harvesting the flower at two days after commercial stage of harvest. **P<sub>0</sub>** : No pulsing (Kept in distilled water), **P<sub>1</sub>** : Pulsing with 5 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours, **P<sub>2</sub>** : Pulsing with 10 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours, **P<sub>3</sub>** : Pulsing with 15 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours



**Figure 2: Cumulative loss of water (CLW) by bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions**

water was observed to be highest with the interaction  $S_2P_2$  (90.23 g/cut flower) and the lowest was found in  $S_1P_0$  (35.70 g/cut flower).

#### **4.1.1.3 Uptake of water : Loss of water**

The data with respect to the ratio of uptake of water and loss of water as influenced by the stages of harvest and pulsing solutions in bird-of-paradise cut flower are presented in Table 3.

Both the ratio of uptake of water and loss of water and the cumulative ratio of uptake of water and loss of water differed significantly between different stages of harvest, pulsing solution and their interactions.

The results indicated that the bird-of-paradise cut flower harvested at commercial stage of harvest ( $S_2$ ) had the highest ratio between water uptake and water loss during the intervals  $D_1$ ,  $D_2$ ,  $D_3$  and  $D_4$  (0.91, 0.89, 0.88 and 0.91 respectively) whereas, the lowest ratio was recorded in flowers harvested two days prior to commercial stage of harvest ( $S_1$ ) during the same intervals (0.83, 0.81, 0.82 and 0.84 respectively). The cumulative ratio of water uptake and water loss also registered highest value in flowers harvested at  $S_2$  (0.90) and lowest in flowers harvested at  $S_1$  (0.82).

The effect of pulsing treatments on the ratio of water uptake and water loss were highest in flowers pulsed with  $P_2$  (10% sucrose + 200ppm 8HQS + 150ppm citric acid for 48 hours) during the intervals  $D_1$ ,  $D_2$ ,  $D_3$  and  $D_4$  (0.93, 0.91, 0.95 and 0.93 respectively). Whereas, the lowest was recorded in  $P_0$  (no pulsing) during the same intervals (0.81, 0.75, 0.74 and 0.77 respectively). The cumulative ratio between uptake of water and loss of water was maximum in  $P_2$  (0.93) and the minimum was in  $P_0$  (0.77).

**Table 3: Ratio of uptake of water and loss of water of bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions**

Uptake of water: Transpiration loss of water (UW:TLW)(g/cut flower)												
Days	<b>D<sub>1</sub></b> (UW:TLW of day 1-4)				<b>D<sub>2</sub></b> (UW:TLW of day 5-8)				<b>D<sub>3</sub></b> (UW:TLW of day 9-12)			
Treatments/Stage	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN
P <sub>0</sub>	0.75	0.84	0.84	0.81	0.72	0.78	0.77	0.75	0.71	0.75	0.75	0.74
P <sub>1</sub>	0.84	0.95	0.90	0.90	0.82	0.95	0.85	0.87	0.82	0.94	0.92	0.90
P <sub>2</sub>	0.90	0.97	0.93	0.93	0.87	0.96	0.91	0.91	0.92	0.97	0.96	0.95
P <sub>3</sub>	0.83	0.89	0.88	0.87	0.83	0.87	0.85	0.85	0.81	0.87	0.86	0.85
MEAN	0.83	0.91	0.89		0.81	0.89	0.84		0.82	0.88	0.87	
	S	T	S×T		S	T	S×T		S	T	S×T	
F test	*	*	*		*	*	*		*	*	*	
SEm±	0.003	0.003	0.006		0.005	0.006	0.01		0.004	0.005	0.01	
CD@5%	0.008	0.010	0.017		0.014	0.016	0.028		0.013	0.015	0.026	

Days	<b>D<sub>4</sub></b> (UW:TLW of day 13-16)				<b>CUW:CLW</b> (Cumulative UW : Cumulative TLW)			
Treatments/Stage	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN
P <sub>0</sub>	0.69	0.83	0.78	0.77	0.72	0.80	0.79	0.77
P <sub>1</sub>	0.88	0.93	0.91	0.91	0.84	0.94	0.90	0.89
P <sub>2</sub>	0.89	0.96	0.95	0.93	0.89	0.96	0.93	0.93
P <sub>3</sub>	0.89	0.91	0.91	0.91	0.84	0.88	0.87	0.87
MEAN	0.84	0.91	0.89		0.82	0.90	0.87	
	S	T	S×T		S	T	S×T	
F test	*	*	*		*	*	*	
SEm±	0.004	0.005	0.008		0.003	0.003	0.005	
CD@5%	0.012	0.014	0.024		0.007	0.009	0.015	

**S<sub>1</sub>** : Harvesting the flower at two days before commercial stage of harvest, **S<sub>2</sub>** : Harvesting the flower at commercial stage of harvest, **S<sub>3</sub>** : Harvesting the flower at two days after commercial stage of harvest. **P<sub>0</sub>** : No pulsing (Kept in distilled water), **P<sub>1</sub>** : Pulsing with 5 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours, **P<sub>2</sub>** : Pulsing with 10 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours, **P<sub>3</sub>** : Pulsing with 15 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours

The highest value among the interaction of stages of harvest and pulsing treatments was recorded in S<sub>2</sub>P<sub>2</sub> (cut flowers harvested at commercial stage and pulsed with 10% sucrose + 200ppm 8HQS + 150ppm citric acid for 48 hours) during the intervals D<sub>1</sub>, D<sub>2</sub>, D<sub>3</sub> and D<sub>4</sub> (0.97, 0.96, 0.97 and 0.96 respectively). The lowest ratio was found with interaction of S<sub>1</sub>P<sub>0</sub> (cut flowers harvested two days before commercial stage and no pulsing) during the same interval (0.75, 0.72, 0.71 and 0.69 respectively). The value registered for cumulative ratio between uptake of water and loss of water was highest in S<sub>2</sub>P<sub>2</sub> (0.96) and the lowest was in S<sub>1</sub>P<sub>0</sub> (0.72).

#### **4.1.1.4 Water balance (g/cut flower)**

The data relating to the water balance as affected by stages of harvest and pulsing solutions in bird-of-paradise cut flower are shown in Table 4.

Both the water balance and cumulative water balance differed significantly between different stages of harvest, pulsing solution and their interactions.

The effect of stage of harvest on water balance of bird-of-paradise cut flowers was maximum in flowers harvested at commercial stage of harvest (S<sub>2</sub>) during the intervals D<sub>1</sub>, D<sub>2</sub>, D<sub>3</sub> and D<sub>4</sub> (-1.58, -1.51, -1.41 and -0.89 g/cut flower, respectively) and the lowest was observed in flowers harvested two days prior to commercial stage of harvest (S<sub>1</sub>) during the same intervals (-2.83, -2.38, -1.99 and -1.13 g/cut flower, respectively). The cumulative water balance was also found highest in flowers harvested at S<sub>2</sub> (-5.39 g/cut flower) and lowest in flowers harvested at S<sub>1</sub> (-8.33 g/cut flower).

The water balance of bird-of-paradise cut flower as influenced by pulsing treatment was highest in flowers pulsed with P<sub>2</sub> (10% sucrose +

**Table 4: Water balance of bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions**

Water balance (WB)(g/cut flower)												
Days	<b>D<sub>1</sub></b> (WB of day 1-4)				<b>D<sub>2</sub></b> (WB of day 5-8)				<b>D<sub>3</sub></b> (WB of day 9-12)			
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN
P <sub>0</sub>	-3.17	-2.17	-2.17	-2.50	-2.57	-2.17	-2.17	-2.30	-2.57	-2.17	-2.27	-2.33
P <sub>1</sub>	-3.00	-1.17	-2.00	-2.06	-2.60	-0.90	-2.17	-1.89	-2.17	-0.83	-1.00	-1.33
P <sub>2</sub>	-2.00	-1.00	-2.00	-1.67	-2.00	-0.97	-2.00	-1.66	-0.90	-0.63	-0.80	-0.78
P <sub>3</sub>	-3.17	-2.00	-2.17	-2.44	-2.33	-2.00	-2.17	-2.17	-2.33	-2.00	-2.00	-2.11
MEAN	-2.83	-1.58	-2.08		-2.38	-1.51	-2.13		-1.99	-1.41	-1.52	
	S	T	S×T		S	T	S×T		S	T	S×T	
F test	*	*	*		*	*	*		*	*	*	
SEm±	0.06	0.07	0.12		0.06	0.07	0.11		0.05	0.05	0.09	
CD@5%	0.17	0.20	0.34		0.17	0.19	0.33		0.13	0.15	0.26	

Days	<b>D<sub>4</sub></b> (WB of day 13-16)				<b>CWB</b> (Cumulative WB)			
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN
P <sub>0</sub>	-1.57	-1.10	-1.40	-1.36	-9.87	-7.60	-8.00	-8.49
P <sub>1</sub>	-1.17	-0.83	-1.00	-1.00	-8.93	-3.73	-6.17	-6.28
P <sub>2</sub>	-0.80	-0.63	-0.80	-0.74	-5.70	-3.23	-5.60	-4.84
P <sub>3</sub>	-1.00	-1.00	-1.00	-1.00	-8.83	-7.00	-7.33	-7.72
MEAN	-1.13	-0.89	-1.05		-8.33	-5.39	-6.78	
	S	T	S×T		S	T	S×T	
F test	*	*	*		*	*	*	
SEm±	0.03	0.03	0.05		0.14	0.16	0.28	
CD@5%	0.08	0.09	0.16		0.40	0.46	0.80	

**S<sub>1</sub>** : Harvesting the flower at two days before commercial stage of harvest, **S<sub>2</sub>** : Harvesting the flower at commercial stage of harvest, **S<sub>3</sub>** : Harvesting the flower at two days after commercial stage of harvest. **P<sub>0</sub>** : No pulsing (Kept in distilled water), **P<sub>1</sub>** : Pulsing with 5 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours, **P<sub>2</sub>** : Pulsing with 10 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours, **P<sub>3</sub>** : Pulsing with 15 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours

200ppm 8HQS + 150ppm citric acid for 48 hours) during the intervals D<sub>1</sub>, D<sub>2</sub>, D<sub>3</sub> and D<sub>4</sub> (-1.67, -1.66, -0.78 and -0.74 g/cut flower, respectively). Whereas, the lowest was recorded in the flowers kept without pulsing (P<sub>0</sub>) during the same intervals (-2.50, -2.30, -2.33 and -1.36 g/cut flower, respectively). The cumulative water balance registered the highest value in flowers pulsed with P<sub>2</sub> (-4.84 g/cut flower) and was lowest in P<sub>0</sub> (-8.49g/cut flower).

The interaction effect of stages of harvest and pulsing treatments on water balance was found highest in S<sub>2</sub>P<sub>2</sub> (cut flowers harvested at commercial stage and pulsed with 10% sucrose + 200ppm 8HQS + 150ppm citric acid for 48 hours) during the interval D<sub>1</sub>, D<sub>2</sub>, D<sub>3</sub> and D<sub>4</sub> (-1.00, -0.97, -0.63 and -0.63 g/cut flower, respectively). The lowest water balance was recorded in S<sub>1</sub>P<sub>0</sub> (cut flowers harvested two days before the commercial stage and no pulsing) during the same interval (-3.17, -2.57, -2.57 and -1.57 g/cut flower, respectively). The cumulative water balance was significantly highest with the interaction S<sub>2</sub>P<sub>2</sub> (-3.23 g/cut flower) and the lowest was in S<sub>1</sub>P<sub>0</sub> (-9.87 g/cut flower, respectively).

#### **4.1.2 Fresh weight of cut flowers (g)**

The data on the fresh weight of bird-of-paradise cut flower as influenced by stages of harvest and pulsing solutions are presented in Table 5.

Significant differences in the fresh weight of the bird-of-paradise cut flowers between different stages of harvest, pulsing solution and their interactions were observed on 4<sup>th</sup> 8<sup>th</sup> 12<sup>th</sup> and 16<sup>th</sup> day.

It is seen from the table that the bird-of-paradise cut flower harvested at commercial stage of harvest (S<sub>2</sub>) had the highest fresh weight on 4<sup>th</sup> 8<sup>th</sup> 12<sup>th</sup> and 16<sup>th</sup> day (120.83, 119.16, 117.75 and 116.86 g,

**Table 5: Fresh weight of bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions**

Fresh weight (g/cut flower)												
Days	DAY 0				DAY 4				DAY 8			
Treatments/Stage	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN
P <sub>0</sub>	121.67	122.00	122.33	122.00	118.50	119.83	120.17	119.50	115.93	117.67	118.00	117.20
P <sub>1</sub>	120.67	122.33	122.67	121.89	117.67	121.17	120.67	119.83	115.07	120.27	118.50	117.94
P <sub>2</sub>	122.33	122.33	122.33	122.33	120.33	122.00	120.33	120.89	118.33	120.37	118.33	119.01
P <sub>3</sub>	123.33	122.33	120.67	122.11	120.17	120.33	118.50	119.67	117.83	118.33	116.33	117.50
MEAN	122.00	122.25	122.00		119.17	120.83	119.92		116.79	119.16	117.79	
	S	T	S×T		S	T	S×T		S	T	S×T	
F test	NS	NS	NS		*	*	*		*	*	*	
SEm±	0.33	0.38	0.66		0.31	0.36	0.62		0.35	0.40	0.70	
CD@5%	-	-	-		0.91	1.05	1.82		1.02	1.18	2.04	

Days	DAY 12				DAY 16			
Treatments/Stage	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN
P <sub>0</sub>	113.37	115.50	115.73	114.87	111.80	114.40	114.33	113.51
P <sub>1</sub>	112.90	119.43	117.50	116.61	111.73	118.60	116.50	115.61
P <sub>2</sub>	117.43	119.73	117.53	118.23	116.63	119.10	116.73	117.49
P <sub>3</sub>	115.50	116.33	114.33	115.39	114.50	115.33	113.33	114.39
MEAN	114.80	117.75	116.28		113.67	116.86	115.23	
	S	T	S×T		S	T	S×T	
F test	*	*	*		*	*	*	
SEm±	0.38	0.44	0.76		0.39	0.45	0.78	
CD@5%	1.11	1.28	2.21		1.14	1.31	2.28	

**NS** : Non significant, **S<sub>1</sub>** : Harvesting the flower at two days before commercial stage of harvest, **S<sub>2</sub>** : Harvesting the flower at commercial stage of harvest, **S<sub>3</sub>** : Harvesting the flower at two days after commercial stage of harvest. **P<sub>0</sub>** : No pulsing (Kept in distilled water), **P<sub>1</sub>** : Pulsing with 5 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours, **P<sub>2</sub>** : Pulsing with 10 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours, **P<sub>3</sub>** : Pulsing with 15 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours

respectively) and the lowest was recorded in flowers harvested two days prior to commercial stage of harvest ( $S_1$ ) on same days (119.17, 1116.79, 114.80 and 113.67 g, respectively).

The results indicated that the bird-of-paradise flowers pulsed with  $P_2$  (10% sucrose + 200ppm 8HQS + 150ppm citric acid for 48 hours) recorded the highest fresh weight on day 4<sup>th</sup> 8<sup>th</sup> 12<sup>th</sup> and 16<sup>th</sup> (120.89, 119.01, 118.23 and 117.49 g, respectively) whereas, the flowers kept without pulsing ( $P_0$ ) recorded the lowest value on same days (119.50, 119.01, 114.87 and 113.51 g, respectively).

The interaction effect of stages of harvest and pulsing treatments on fresh weight of the cut flower recorded maximum value in  $S_2P_2$  (cut flowers harvested at commercial stage and pulsed with 10% sucrose + 200ppm 8HQS + 150ppm citric acid for 48 hours) on day 4<sup>th</sup> 8<sup>th</sup> 12<sup>th</sup> and 16<sup>th</sup> day (122.00, 120.37, 119.73 and 119.10 g, respectively) and the lowest fresh weight was recorded with interaction of  $S_1P_0$  (cut flowers harvested two days before commercial stage and no pulsing) during the same interval (118.50, 115.93, 113.37 and 111.80 g, respectively).

#### **4.1.3 Physiological loss in weight of cut flowers (%)**

The data on the physiological loss in weight of bird-of-paradise cut flower as influenced by stages of harvest, pulsing treatments and their interactions are presented in Table 6 and Figure 3.

Both the physiological loss in weight and cumulative physiological loss in weight differed significantly between different stages of harvest, pulsing solution and their interactions.

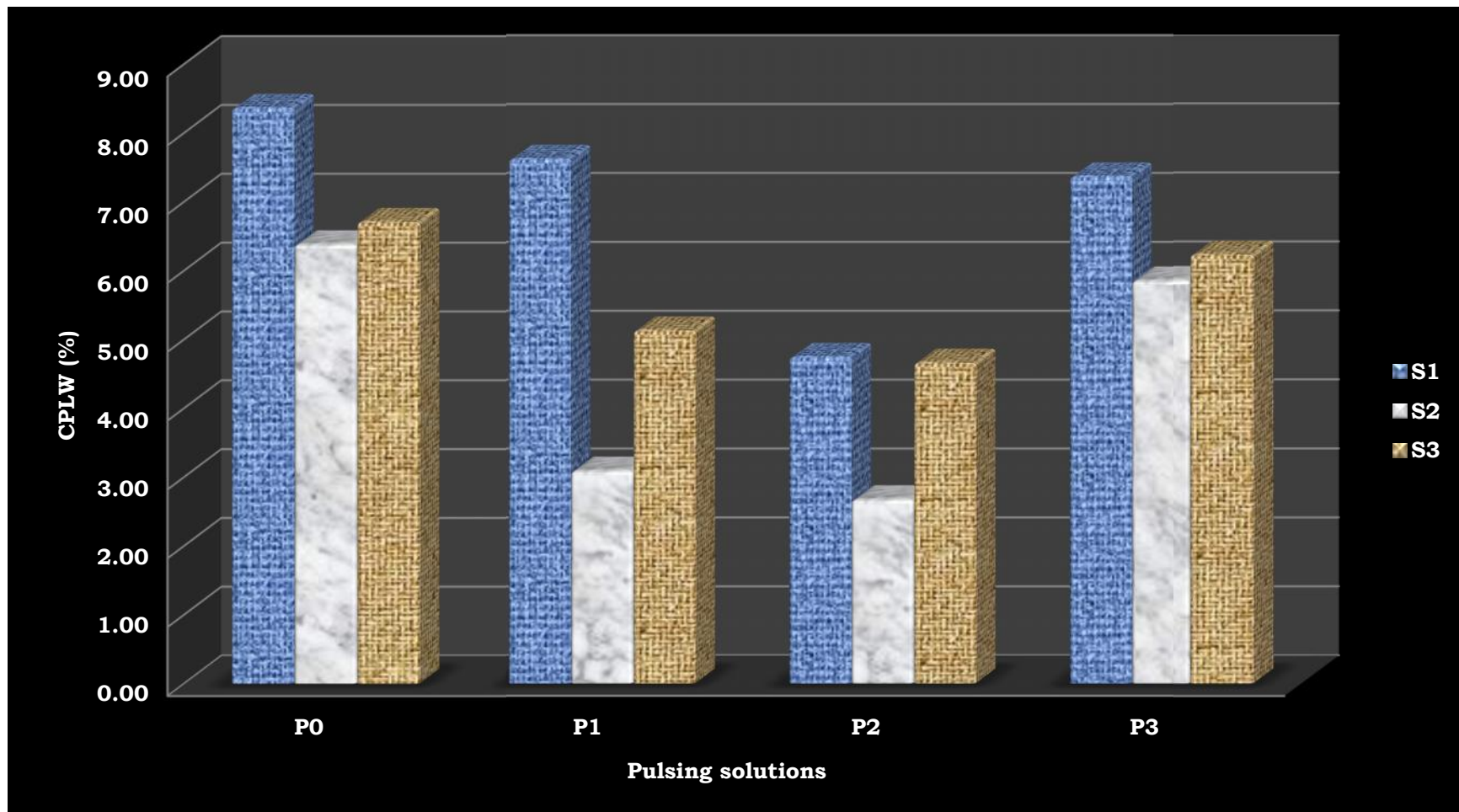
The lowest physiological loss in weight was observed in the cut flowers harvested at commercial stage of harvest ( $S_2$ ) during the intervals  $D_1$ ,  $D_2$ ,  $D_3$  and  $D_4$  (1.30, 1.25, 1.19 and 0.76 %, respectively) and the

**Table 6: Physiological loss in weight of bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions**

Physiological loss in weight (PLW%)												
Days	<b>D<sub>1</sub></b> (PLW of day 1-4)				<b>D<sub>2</sub></b> (PLW of day 5-8)				<b>D<sub>3</sub></b> (PLW of day 9-12)			
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN
P <sub>0</sub>	2.60	1.78	1.77	2.05	2.17	1.81	1.74	1.90	2.21	1.84	1.86	1.97
P <sub>1</sub>	2.49	0.95	1.63	1.69	2.21	0.74	1.80	1.58	1.88	0.69	0.84	1.14
P <sub>2</sub>	1.63	0.82	1.63	1.36	1.66	0.80	1.66	1.37	0.76	0.53	0.68	0.65
P <sub>3</sub>	2.57	1.63	1.80	2.00	1.94	1.66	1.83	1.81	1.98	1.69	1.72	1.80
MEAN	2.32	1.30	1.71		2.00	1.25	1.76		1.71	1.19	1.27	
	S	T	S×T		S	T	S×T		S	T	S×T	
F test	*	*	*		*	*	*		*	*	*	
SEm±	0.05	0.06	0.10		0.05	0.05	0.09		0.04	0.05	0.08	
CD@5%	0.14	0.16	0.28		0.14	0.16	0.27		0.11	0.13	0.23	

Days	<b>D<sub>4</sub></b> (PLW of day 13-16)				<b>CPLW</b> (Cumulative PLW)			
	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN
P <sub>0</sub>	1.38	0.95	1.21	1.18	8.37	6.38	6.71	7.15
P <sub>1</sub>	1.03	0.70	0.85	0.86	7.61	3.09	5.12	5.27
P <sub>2</sub>	0.68	0.53	0.68	0.63	4.74	2.67	4.65	4.02
P <sub>3</sub>	0.87	0.86	0.87	0.87	7.36	5.85	6.22	6.47
MEAN	0.99	0.76	0.90		7.02	4.50	5.68	
	S	T	S×T		S	T	S×T	
F test	*	*	*		*	*	*	
SEm±	0.02	0.03	0.05		0.12	0.14	0.25	
CD@5%	0.07	0.08	0.14		0.36	0.42	0.73	

**S<sub>1</sub>** : Harvesting the flower at two days before commercial stage of harvest, **S<sub>2</sub>** : Harvesting the flower at commercial stage of harvest, **S<sub>3</sub>** : Harvesting the flower at two days after commercial stage of harvest. **P<sub>0</sub>** : No pulsing (Kept in distilled water), **P<sub>1</sub>** : Pulsing with 5 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours, **P<sub>2</sub>** : Pulsing with 10 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours, **P<sub>3</sub>** : Pulsing with 15 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours



**Figure 3: Cumulative physiological loss in weight (CPLW) of bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions**

highest was recorded in flowers harvested two days prior to commercial stage of harvest ( $S_1$ ) during the same intervals (2.32, 2.00, 1.71 and 0.99 %, respectively). The lowest cumulative physiological loss in weight was observed in flowers harvested at  $S_2$  (4.50%) and the highest in flowers harvested at  $S_1$  (7.02%)

The effect of pulsing treatments on physiological loss in weight of bird-of-paradise cut flower was lowest in flowers pulsed with  $P_2$  (10% sucrose + 200ppm 8HQS + 150ppm citric acid for 48 hours) during the intervals  $D_1$ ,  $D_2$ ,  $D_3$  and  $D_4$  (1.36, 1.37, 0.65 and 0.63%, respectively) and the highest was in the flowers kept without pulsing ( $P_0$ ) during the same intervals (2.05, 1.90, 1.97 and 1.18%, respectively). The cumulative physiological loss in weight recorded was lowest in flowers pulsed with  $P_2$  (4.02%) whereas, the highest loss was observed in  $P_0$  (7.15%).

The interaction effect of stages of harvest and pulsing treatments on physiological loss in weight was lowest in  $S_2P_2$  (cut flowers harvested at commercial stage and pulsed with 10% sucrose + 200ppm 8HQS + 150ppm citric acid for 48 hours) during the intervals  $D_1$ ,  $D_2$ ,  $D_3$  and  $D_4$  (0.82, 0.80, 0.53 and 0.53%, respectively) whereas, the highest loss in weight was recorded in  $S_1P_0$  (cut flowers harvested two days before the commercial stage and no pulsing) during the same interval (2.60, 2.17, 2.21 and 1.38%, respectively). The observed value of cumulative physiological loss in weight was lowest in  $S_2P_2$  (2.67%) and the highest was in  $S_1P_0$  (8.37%).

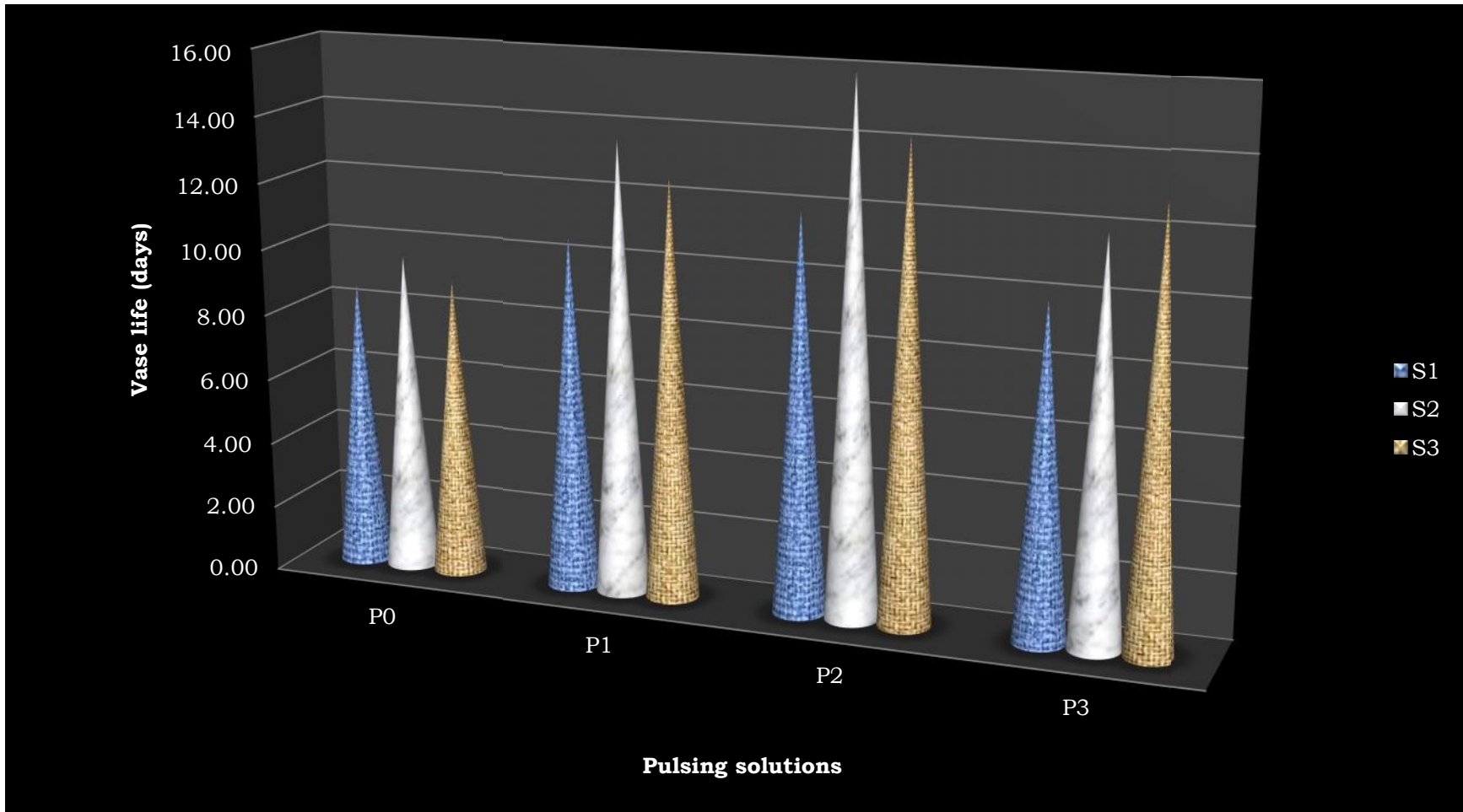
#### **4.1.4 Vase life of cut flowers (days)**

The data pertaining to the vase life of bird-of-paradise cut flower as influenced by the stages of harvest and pulsing solutions are depicted in Table 7 and Figure 4.

**Table 7: Vase life of bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions**

Vaselife (Days)				
Treatments/Stage	S <sub>1</sub>	S <sub>2</sub>	S <sub>3</sub>	MEAN
P <sub>0</sub>	8.67	9.67	9.00	9.11
P <sub>1</sub>	10.67	13.67	12.67	12.33
P <sub>2</sub>	12.00	16.00	14.33	14.11
P <sub>3</sub>	10.00	12.00	13.00	11.67
MEAN	10.33	12.83	12.25	
	S	T	S×T	
F test	*	*	*	
SEm±	0.26	0.30	0.53	
CD@5%	0.77	0.89	1.54	

**S<sub>1</sub>** : Harvesting the flower at two days before commercial stage of harvest, **S<sub>2</sub>** : Harvesting the flower at commercial stage of harvest, **S<sub>3</sub>** : Harvesting the flower at two days after commercial stage of harvest. **P<sub>0</sub>** : No pulsing (Kept in distilled water), **P<sub>1</sub>** : Pulsing with 5 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours, **P<sub>2</sub>** : Pulsing with 10 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours, **P<sub>3</sub>** : Pulsing with 15 per cent Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours



**Figure 4: Vase life of bird-of-paradise cut flowers as influenced by stage of harvest and pulsing solutions**

The vase life of bird-of-paradise cut flower differed significantly between different stages of harvest, pulsing solution and their interactions.

The results revealed that the vase life of bird-of-paradise cut flower harvested at commercial stage of harvest ( $S_2$ ) had maximum vase life (12.83 days) and the minimum was recorded in  $S_1$  (10.33 days).

The effect of pulsing treatments on the vase life of bird-of-paradise cut flowers was highest in flowers pulsed with 10 per cent sucrose + 200ppm 8HQS + 150ppm citric acid for 48 hours ( $P_2$ )(14.11 days) and the lowest was in  $P_0$  (9.11 days).

The interaction of stages of harvest and pulsing treatments on vase life of cut flower was found highest in  $S_2P_2$  (cut flowers harvested at commercial stage and pulsed with 10% sucrose + 200ppm 8HQS + 150ppm citric acid for 48 hours) (16.00 days) and the lowest was in  $S_1P_0$  (cut flowers harvested two days before commercial stage and no pulsing) during the same interval (8.67 days).

## **4.2 Experiment-II: Effect of floral preservatives and their concentration in the holding solution on the quality and vase life of bird-of-paradise harvested at commercial stage of harvest**

### **4.2.1 Water relations**

The results on the water relation *viz.*, uptake of water, transpiration loss of water, ratio of water uptake and water loss and water balance pertaining to the cut flowers of bird-of-paradise as influenced by holding solutions are viewed here under.

#### **4.2.1.1 Uptake of water (g/cut flower)**

The data relating to the uptake of water by bird-of-paradise cut flower as influenced by holding solutions are traced in Table 8 and Figure 5.

Both the uptake of water and cumulative uptake of water differed significantly between the treatments throughout the period of vase life.

It is clearly evident from the table that , the bird-of-paradise cut flower held in a solution containing 10 per cent sucrose + silver thiosulphate 100ppm + citric acid 150ppm + 8HQS 250ppm (T<sub>17</sub>) had higher uptake of water during the intervals D<sub>1</sub> (uptake of water of day 1-4), D<sub>2</sub> (uptake of water of day 5-8), D<sub>3</sub> (uptake of water of day 9-12) and D<sub>4</sub> (uptake of water of day 13-15) (27.50, 20.44, 18.50 and 14.20 g/cut flower, respectively) and those flowers held in distilled water (T<sub>1</sub>) had lower uptake of water during the same interval (8.00, 6.94, 7.17, 3.94 g/cut flower, respectively).

Similarly the maximum cumulative uptake of water was recorded in T<sub>17</sub> (80.64 g/cut flower) whereas, T<sub>1</sub> (distilled water) recorded the minimum cumulative water uptake (26.04 g/cut flower).

#### **4.2.1.2 Loss of water (g/cut flower)**

The data pertaining to the loss of water by bird-of-paradise cut flower as influenced by holding solutions is furnished in Table 9 and depicted in Figure 6.

Both the loss of water and cumulative loss of water differed significantly between the different holding solutions used in the experiment.

**Table 8: Uptake of water by bird-of-paradise cut flowers as influenced by holding solutions**

Treatments	Uptake of water(UW) (g/cut flower)				
	D <sub>1</sub> ( UW of day 1-4)	D <sub>2</sub> ( UW of day 5-8)	D <sub>3</sub> (UW of day 9-12)	D <sub>4</sub> (UW of day 13-15)	CUW (Cumulative UW)
T1	8.00	6.94	7.17	3.94	26.04
T2	13.50	11.77	10.50	5.67	41.44
T3	10.00	10.00	8.00	4.17	32.17
T4	14.00	12.50	10.00	5.94	42.44
T5	10.34	9.67	8.34	4.77	33.10
T6	8.50	8.44	7.70	4.37	29.00
T7	8.17	7.94	7.30	4.17	27.57
T8	15.50	12.50	10.50	5.50	44.00
T9	15.67	13.84	11.50	6.34	47.34
T10	21.10	17.44	18.17	13.10	69.80
T11	19.17	16.00	15.50	11.27	61.94
T12	23.50	18.27	18.17	12.20	72.14
T13	19.90	16.27	16.34	12.67	65.17
T14	17.50	15.44	13.00	7.17	53.10
T15	16.50	14.84	11.50	6.84	49.67
T16	25.50	19.87	17.50	13.50	76.37
T17	27.50	20.44	18.50	14.20	80.64
F test	*	*	*	*	*
SEm±	0.258	0.215	0.258	0.186	0.471
CD@5%	0.744	0.618	0.743	0.534	1.354

T<sub>1</sub>: Distilled water ( Control )

T<sub>2</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 25ppm

T<sub>3</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 50ppm

T<sub>4</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 300ppm

T<sub>5</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 400ppm

T<sub>6</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 50ppm

T<sub>7</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 100ppm

T<sub>8</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 200ppm

T<sub>9</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 250ppm

T<sub>10</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 25ppm

T<sub>11</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 50ppm

T<sub>12</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 300ppm

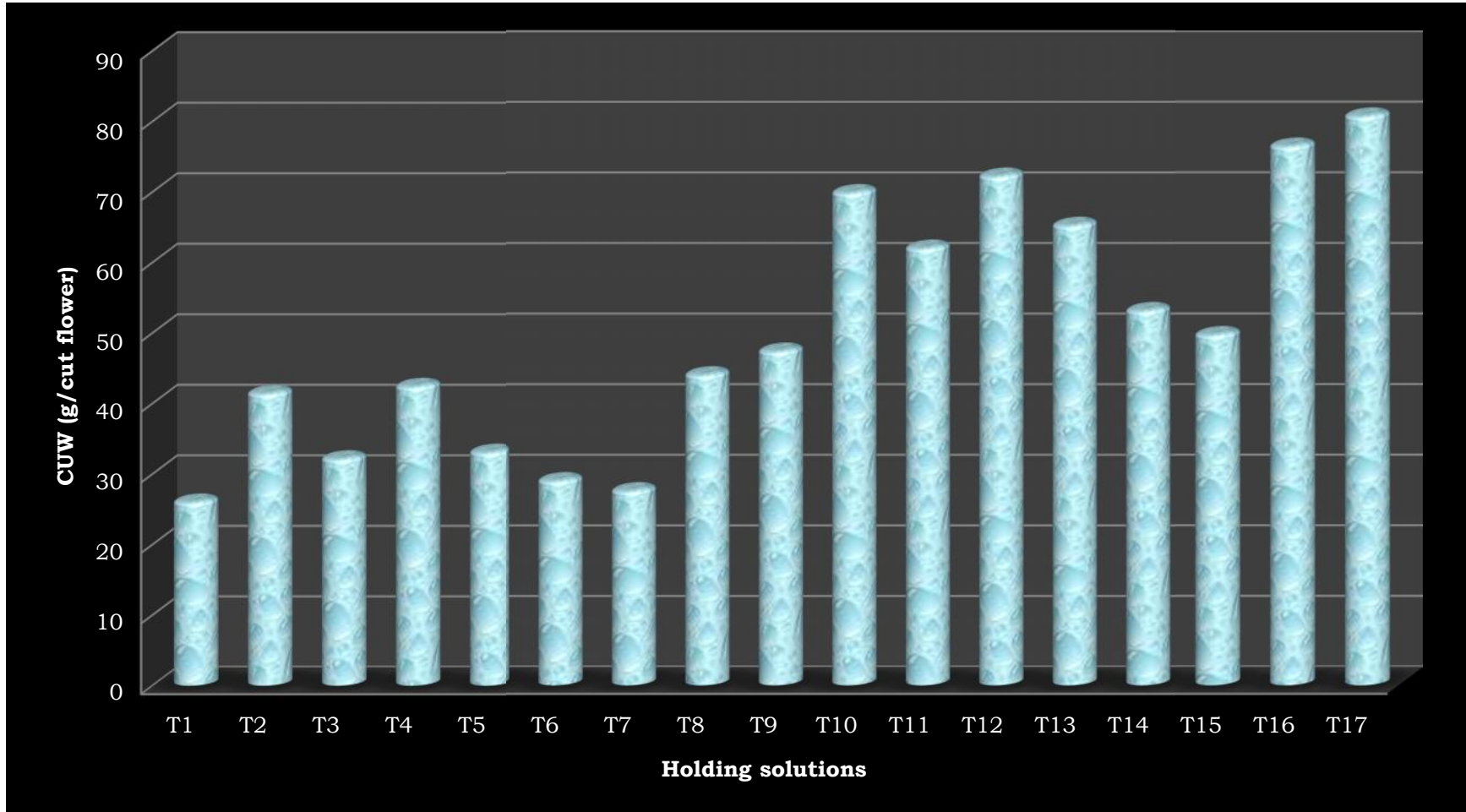
T<sub>13</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 400ppm

T<sub>14</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 50ppm

T<sub>15</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 100ppm

T<sub>16</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 200ppm

T<sub>17</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 250ppm



**Figure 5: Cumulative uptake of water (CUW) by bird-of-paradise cut flowers as influenced by holding solutions**

**Table 9: Loss of water by bird-of-paradise cut flowers as influenced by holding solutions**

Treatments	Loss of water (g/cut flower)				
	D <sub>1</sub> (TLW of day 1-4)	D <sub>2</sub> (TLW of day 5-8)	D <sub>3</sub> (TLW of day 9-12)	D <sub>4</sub> (TLW of day 13-15)	CLW (Cumulative TLW)
T1	11.24	9.34	9.37	5.10	35.04
T2	16.27	13.37	12.30	6.67	48.60
T3	11.97	11.80	9.74	5.24	38.74
T4	16.70	13.94	11.34	6.77	48.74
T5	12.97	11.57	10.07	5.70	40.30
T6	11.20	10.57	9.74	5.30	36.80
T7	10.97	10.20	9.34	5.30	35.80
T8	17.30	13.74	11.57	6.57	49.17
T9	17.47	14.80	12.34	7.17	51.77
T10	21.60	17.94	18.70	13.64	71.87
T11	19.54	16.47	15.94	11.80	63.74
T12	23.90	18.64	18.57	12.70	73.80
T13	20.44	16.70	16.80	13.17	67.10
T14	18.38	16.14	13.64	7.80	55.95
T15	17.25	15.57	12.24	7.57	52.62
T16	26.04	20.27	17.97	14.04	78.30
T17	27.84	20.77	18.87	14.67	82.14
F test	*	*	*	*	*
SEm±	0.280	0.213	0.255	0.184	0.455
CD@5%	0.805	0.612	0.734	0.530	1.308

T<sub>1</sub>: Distilled water ( Control )

T<sub>2</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 25ppm

T<sub>3</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 50ppm

T<sub>4</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 300ppm

T<sub>5</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 400ppm

T<sub>6</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 50ppm

T<sub>7</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 100ppm

T<sub>8</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + 8-Hydroxyquinoline sulphate 200ppm

T<sub>9</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + 8-Hydroxyquinoline sulphate 250ppm

T<sub>10</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 25ppm

T<sub>11</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 50ppm

T<sub>12</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 300ppm

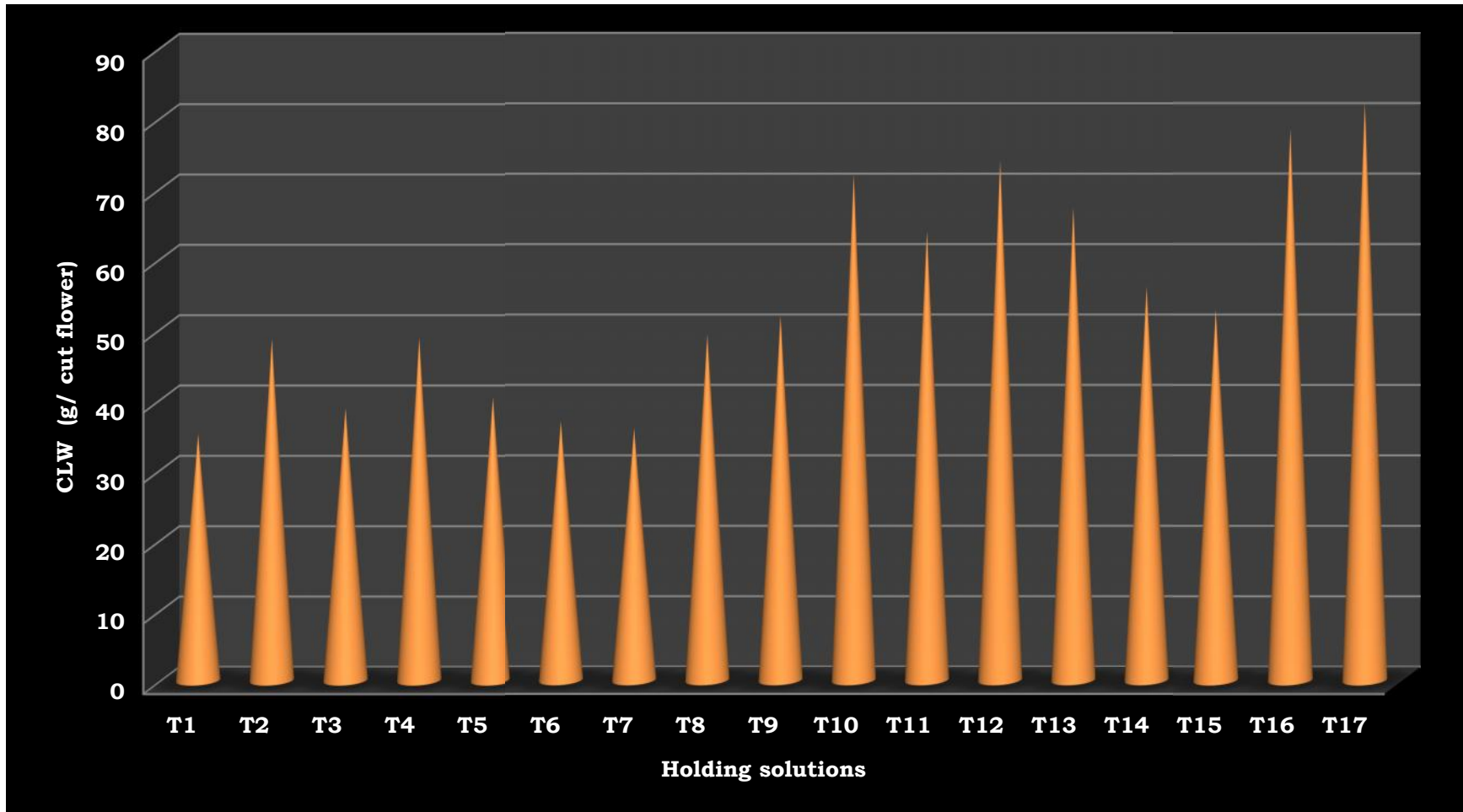
T<sub>13</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 400ppm

T<sub>14</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 50ppm

T<sub>15</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 100ppm

T<sub>16</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + 8-Hydroxyquinoline sulphate 200ppm

T<sub>17</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + 8-Hydroxyquinoline sulphate 250ppm



**Figure 6: Cumulative loss of water (CLW) by bird-of-paradise cut flowers as influenced by holding solutions**

The results indicated that the bird-of-paradise cut flower held in a solution containing 10 per cent sucrose + silver thiosulphate 100ppm + citric acid 150ppm + 8HQS 250ppm (T<sub>17</sub>) had higher loss of water during the interval D<sub>1</sub>, D<sub>2</sub>, D<sub>3</sub> and D<sub>4</sub> (27.84, 20.77, 18.87 and 14.67 g/cut flower, respectively) and the flowers held in distilled water (T<sub>1</sub>) recorded less water loss during the same interval (11.24, 9.34, 9.37 and 5.1 g/cut flower, respectively).

It also revealed that, the cumulative loss of water was higher in flowers held in T<sub>17</sub> (82.14 g/cut flower) whereas, the flowers in T<sub>1</sub> (distilled water) recorded the lowest (35.04 g/cut flower).

#### **4.2.1.3 Uptake of water : loss of water**

The data with respect to the ratio between water uptake and water loss by bird-of-paradise cut flower as influenced by holding solutions are categorized in Table 10.

The ratio and cumulative ratio between uptake of water and loss of water in bird-of-paradise cut flower held in a holding solution differed significantly.

The table reflects that, the bird-of-paradise cut flower held in a holding solution containing 10 per cent sucrose + silver thiosulphate 100ppm + citric acid 150ppm + 8HQS 250ppm (T<sub>17</sub>) had maximum ratio during the intervals D<sub>1</sub>, D<sub>2</sub>, D<sub>3</sub> and D<sub>4</sub> (0.99, 0.98, 0.98 and 0.97 respectively) whereas, the treatment T<sub>1</sub>(distilled water) recorded minimum ratio during the same interval (0.71, 0.74, 0.76 and 0.77 respectively).

The maximum cumulative ratio between uptake of water and loss of water was recorded in flowers held in T<sub>17</sub> (0.98 ) and those flowers held in T<sub>1</sub> (distilled water) recorded the minimum ratio (0.74).

**Table 10: Ratio between uptake of water and loss of water by bird-of-paradise cut flowers as influenced by holding solutions**

Treatments	Uptake of water : Transpiration loss of water (UW:TLW)				CUW :CLW
	D <sub>1</sub> (UW:TLW of day 1-4)	D <sub>2</sub> (UW:TLW of day 5-8)	D <sub>3</sub> ( UW:TLW of day 9-12)	D <sub>4</sub> ( UW:TLW of day13-15)	
T1	0.71	0.74	0.76	0.77	0.74
T2	0.83	0.88	0.85	0.85	0.85
T3	0.834	0.85	0.82	0.79	0.83
T4	0.84	0.90	0.88	0.88	0.87
T5	0.80	0.84	0.83	0.84	0.82
T6	0.76	0.80	0.79	0.82	0.79
T7	0.75	0.78	0.78	0.79	0.77
T8	0.90	0.91	0.91	0.84	0.89
T9	0.90	0.94	0.93	0.88	0.91
T10	0.97	0.97	0.97	0.96	0.97
T11	0.98	0.97	0.97	0.96	0.97
T12	0.98	0.97	0.97	0.96	0.97
T13	0.97	0.97	0.97	0.96	0.97
T14	0.95	0.96	0.95	0.92	0.95
T15	0.96	0.95	0.94	0.91	0.94
T16	0.98	0.98	0.97	0.96	0.97
T17	0.99	0.98	0.98	0.97	0.98
F test	*	*	*	*	*
SEm±	0.005	0.004	0.004	0.007	0.003
CD@5%	0.014	0.013	0.012	0.020	0.009

T1: Distilled water ( Control )

T2: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 25ppm

T3: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 50ppm

T4: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 300ppm

T5: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 400ppm

T6: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 50ppm

T7: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 100ppm

T8: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 200ppm

T9: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 250ppm

T10: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 25ppm

T11: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 50ppm

T12: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 300ppm

T13: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 400ppm

T14: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 50ppm

T15: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 100ppm

T16: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 200ppm

T17: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 250ppm

#### **4.2.1.4 Water balance (g/cut flower)**

The data pertaining to the water balance of bird-of-paradise cut flower as influenced by holding solutions are presented in Table 11.

Both the water balance and cumulative water balance differed significantly between the different holding solutions used in the experiment.

It could be inferred from the table that the water balance of bird-of-paradise cut flower held in a solution containing 10 per cent sucrose + silver thiosulphate 100ppm + citric acid 150ppm + 8HQS 250ppm (T<sub>17</sub>) had higher water balance during the intervals D<sub>1</sub>, D<sub>2</sub>, D<sub>3</sub> and D<sub>4</sub> (-0.34, -0.34, -0.37 and -0.47 g/cut flower, respectively) whereas, the flowers held in distilled water (T<sub>1</sub>) recorded lower water balance during the same intervals (-3.24, -2.40, -2.20 and -1.17 g/cut flower, respectively).

Similarly the cumulative water balance was higher in flowers held in T<sub>17</sub> (-1.50 g/cut flower) whereas, the flowers in T<sub>1</sub> (distilled water) recorded the lowest (-9.00 g/cut flower).

#### **4.2.2 Fresh weight of cut flowers (g)**

The data related to the fresh weight of bird-of-paradise cut flower as influenced by holding solutions is depicted in Table 12.

The difference in the fresh weight of the cut flowers held in different holding solutions were found significant on 4<sup>th</sup> 8<sup>th</sup> 12<sup>th</sup> and 15<sup>th</sup> day of vase life.

The fresh weight of the bird-of-paradise cut flower was found highest when held in a solution containing 10 per cent sucrose + silver thiosulphate 100ppm + citric acid 150ppm + 8HQS 250ppm (T<sub>17</sub>) on 4<sup>th</sup> 8<sup>th</sup> 12<sup>th</sup> and 15<sup>th</sup> day (122.67, 122.34, 121.97 and 121.50 g, respectively)

**Table 11: Water balance of bird-of-paradise cut flowers as influenced by holding solutions**

Treatments	Water balance(WB) (g/cut flower)				
	D <sub>1</sub> (WB of day 1-4)	D <sub>2</sub> (WB of day 5-8)	D <sub>3</sub> (WB of day 9-12)	D <sub>4</sub> (WB of day 13-15)	CWB (Cumulative WB)
T1	-3.24	-2.40	-2.20	-1.17	-9.00
T2	-2.77	-1.60	-1.80	-1.00	-7.17
T3	-1.97	-1.80	-1.74	-1.07	-6.57
T4	-2.70	-1.44	-1.34	-0.84	-6.30
T5	-2.64	-1.90	-1.74	-0.94	-7.20
T6	-2.70	-2.14	-2.04	-0.94	-7.80
T7	-2.80	-2.27	-2.04	-1.14	-8.24
T8	-1.80	-1.24	-1.07	-1.07	-5.17
T9	-1.80	-0.97	-0.84	-0.84	-4.44
T10	-0.50	-0.50	-0.54	-0.54	-2.07
T11	-0.37	-0.47	-0.44	-0.54	-1.80
T12	-0.40	-0.37	-0.40	-0.50	-1.67
T13	-0.54	-0.44	-0.47	-0.50	-1.94
T14	-0.88	-0.70	-0.64	-0.64	-2.85
T15	-0.75	-0.74	-0.74	-0.74	-2.95
T16	-0.54	-0.40	-0.47	-0.54	-1.94
T17	-0.34	-0.34	-0.37	-0.47	-1.50
F test	*	*	*	*	*
SEm±	0.087	0.047	0.041	0.041	0.136
CD@5%	0.249	0.134	0.117	0.117	0.39

T1: Distilled water ( Control )

T2: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 25ppm

T3: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 50ppm

T4: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 300ppm

T5: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 400ppm

T6: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 50ppm

T7: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 100ppm

T8: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 200ppm

T9: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 250ppm

T10: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 25ppm

T11: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 50ppm

T12: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 300ppm

T13: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 400ppm

T14: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 50ppm

T15: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 100ppm

T16: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 200ppm

T17: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 250ppm

**Table 12: Fresh weight of bird-of-paradise cut flowers as influenced by holding solutions**

Treatments	Fresh weight (g/cut flower)				
	0 Day	4 <sup>th</sup> Day	8 <sup>th</sup> Day	12 <sup>th</sup> Day	16 <sup>th</sup> Day
T1	121.00	117.77	115.37	113.17	112.00
T2	120.67	117.90	116.30	114.50	113.50
T3	121.00	119.04	117.24	115.50	114.44
T4	121.67	118.97	117.54	116.20	115.37
T5	121.67	119.04	117.14	115.40	114.47
T6	120.67	117.97	115.84	113.80	112.87
T7	121.00	118.20	115.94	113.90	112.77
T8	121.00	119.20	117.97	116.90	115.84
T9	121.00	119.20	118.24	117.40	116.57
T10	121.00	120.50	120.00	119.47	118.94
T11	121.00	120.64	120.17	119.74	119.20
T12	120.34	119.94	119.57	119.17	118.67
T13	122.00	121.47	121.04	120.57	120.07
T14	120.34	119.46	118.76	118.13	117.49
T15	120.67	119.92	119.19	118.45	117.72
T16	121.34	120.80	120.4	119.94	119.40
T17	123.00	122.67	122.34	121.97	121.50
F test	NS	*	*	*	*
SEm±	0.71	0.721	0.708	0.708	0.701
CD@5%	-	2.073	2.035	2.033	2.014

T<sub>1</sub>: Distilled water ( Control )

T<sub>2</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 25ppm

T<sub>3</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 50ppm

T<sub>4</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 300ppm

T<sub>5</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 400ppm

T<sub>6</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 50ppm

T<sub>7</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 100ppm

T<sub>8</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 200ppm

T<sub>9</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 250ppm

T<sub>10</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 25ppm

T<sub>11</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 50ppm

T<sub>12</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 300ppm

T<sub>13</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 400ppm

T<sub>14</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 50ppm

T<sub>15</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 100ppm

T<sub>16</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 200ppm

T<sub>17</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 250ppm

whereas, the flowers held in distilled water (T<sub>1</sub>) recorded the minimum fresh weight during the same intervals (117.77, 115.37, 113.17 and 112.00 g, respectively).

#### **4.2.3 Physiological loss in weight of cut flowers (%)**

The data pertaining to the physiological loss in weight of bird-of-paradise cut flower held in different holding solutions are viewed in Table 13 and Figure 7.

The physiological loss in weight and cumulative physiological loss in weight differed significantly between the different holding solution used in the experiment.

It is seen from the table that , the bird-of-paradise cut flower held in a solution containing 10 per cent sucrose + silver thiosulphate 100ppm + citric acid 150ppm + 8HQS 250ppm (T<sub>17</sub>) had lower physiological loss in weight during the intervals D<sub>1</sub>, D<sub>2</sub>, D<sub>3</sub> and D<sub>4</sub> (0.28, 0.28, 0.30 and 0.39%, respectively) and those flowers held in distilled water (T<sub>1</sub>) recorded the highest physiological loss during the same intervals (2.68, 2.04, 1.91 and 1.03%, respectively).

The results also revealed that cumulative physiological loss in weight was lowest in T<sub>17</sub> (1.23%) and highest in T<sub>1</sub> (distilled water) (7.65%).

#### **4.2.4 Vase life of cut flowers (days)**

The data pertaining to the vase life of bird-of-paradise cut flowers held in different holding solutions are tabulated in Table 14 and depicted in Figure 8.

The vase life of the bird-of-paradise cut flowers held in the different holding solutions differed significantly.

**Table 13: Physiological loss in weight of bird-of-paradise cut flowers as influenced by holding solutions**

Treatments	Physiological loss in weight (PLW %)				
	D <sub>1</sub> (PLW of day1-4)	D <sub>2</sub> (PLW of day 5-8)	D <sub>3</sub> (PLW of day 9-12)	D <sub>4</sub> (PLW of day 13-15)	CPLW (Cumulative PLW)
T1	2.68	2.04	1.91	1.03	7.65
T2	2.30	1.36	1.55	0.88	6.08
T3	1.63	1.52	1.48	0.93	5.54
T4	2.23	1.21	1.14	0.72	5.28
T5	2.17	1.60	1.48	0.81	6.06
T6	2.24	1.81	1.76	0.82	6.63
T7	2.32	1.92	1.76	1.00	6.98
T8	1.49	1.04	0.91	0.92	4.35
T9	1.49	0.82	0.71	0.72	3.72
T10	0.42	0.42	0.45	0.45	1.72
T11	0.31	0.39	0.37	0.45	1.50
T12	0.34	0.31	0.34	0.42	1.40
T13	0.44	0.36	0.39	0.42	1.60
T14	0.73	0.59	0.54	0.54	2.39
T15	0.63	0.62	0.62	0.62	2.47
T16	0.44	0.34	0.39	0.45	1.61
T17	0.28	0.28	0.30	0.39	1.23
F test	*	*	*	*	*
SEm±	0.073	0.038	0.035	0.035	0.115
CD@5%	0.209	0.107	0.101	0.1	0.328

T<sub>1</sub>: Distilled water ( Control )

T<sub>2</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 25ppm

T<sub>3</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 50ppm

T<sub>4</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 300ppm

T<sub>5</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 400ppm

T<sub>6</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 50ppm

T<sub>7</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 100ppm

T<sub>8</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 200ppm

T<sub>9</sub>: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 250ppm

T<sub>10</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 25ppm

T<sub>11</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 50ppm

T<sub>12</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 300ppm

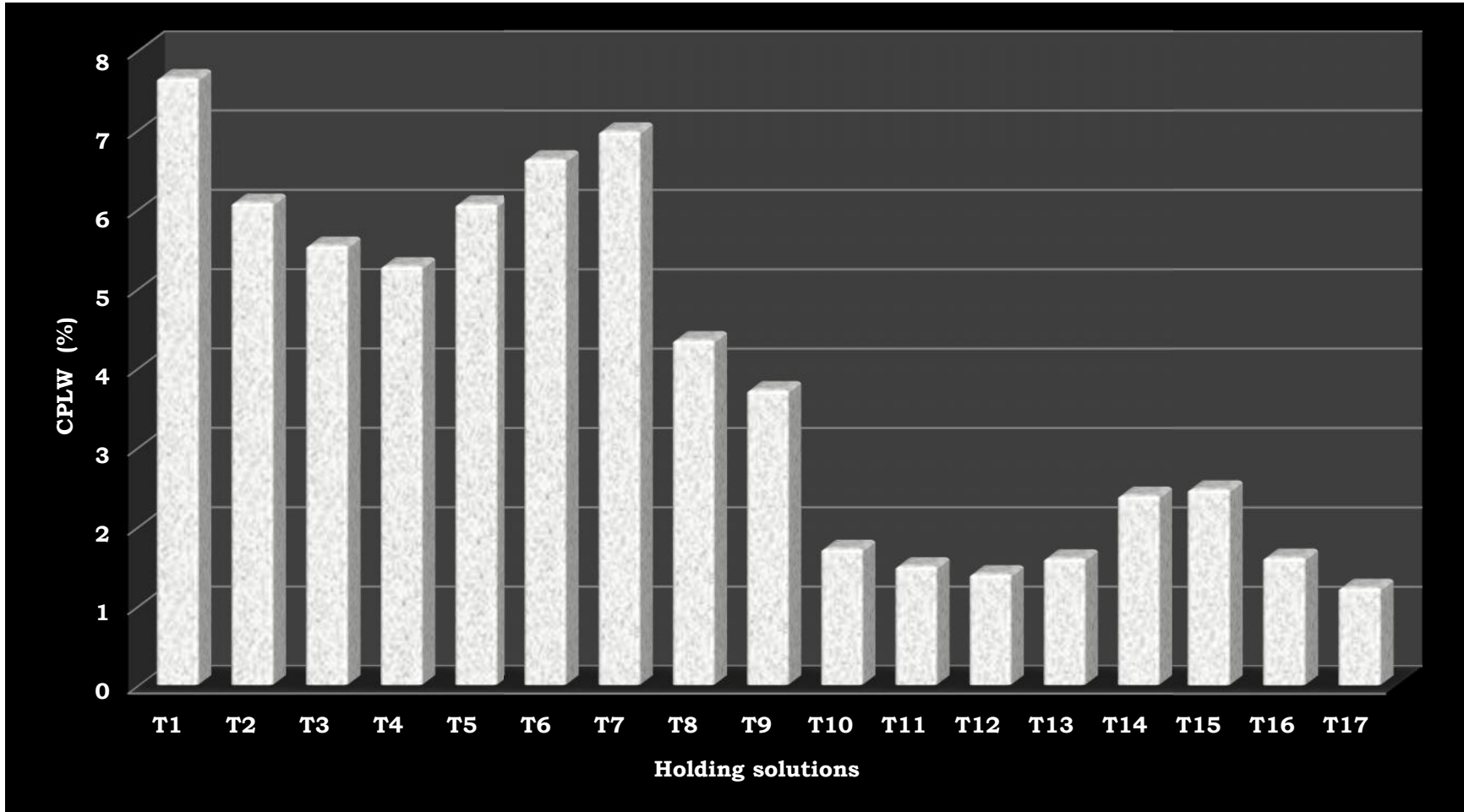
T<sub>13</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 400ppm

T<sub>14</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 50ppm

T<sub>15</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 100ppm

T<sub>16</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 200ppm

T<sub>17</sub>: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 250ppm



**Figure 7: Cumulative physiological loss in weight (CPLW) of bird-of-paradise cut flowers as influenced by holding solutions**

**Table 14: Vase life of bird-of-paradise cut flowers as influenced by holding solutions**

<b>Treatments</b>	<b>Vase life (Days)</b>
T1	9.00
T2	12.34
T3	11.34
T4	12.67
T5	11.34
T6	11.00
T7	10.34
T8	12.67
T9	13.00
T10	14.34
T11	13.67
T12	14.00
T13	14.00
T14	13.34
T15	13.67
T16	14.67
T17	15.33
F test	*
SEm±	0.44
CD@5%	1.27

T1: Distilled water ( Control )

T2: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 25ppm

T3: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 50ppm

T4: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 300ppm

T5: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 400ppm

T6: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 50ppm

T7: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 100ppm

T8: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 200ppm

T9: 5% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 250ppm

T10: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 25ppm

T11: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Silver nitrate 50ppm

T12: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 300ppm

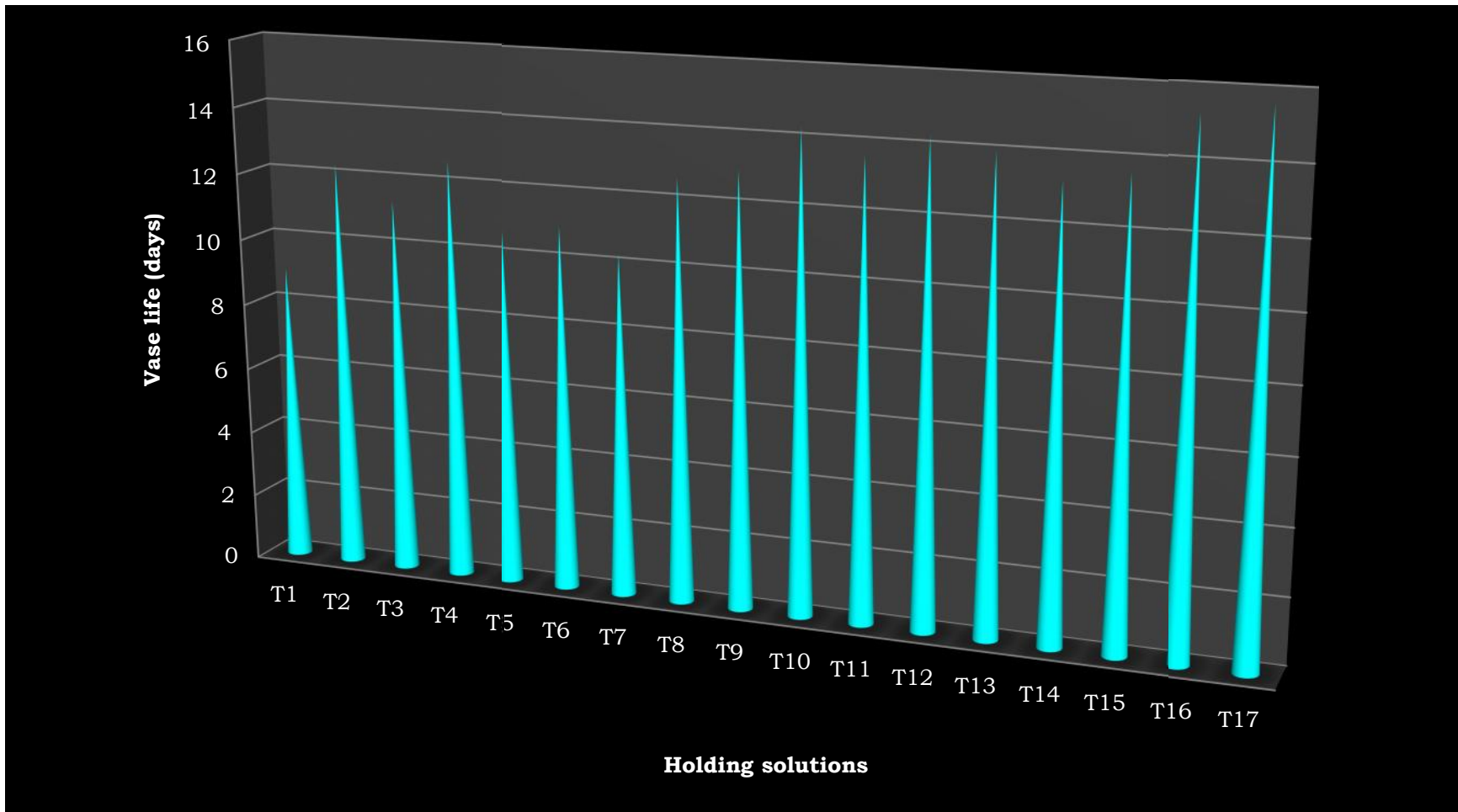
T13: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Aluminium sulphate 400ppm

T14: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 50ppm

T15: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm + Sodium hypochlorite 100ppm

T16: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 200ppm

T17: 10% Sucrose + Silver thiosulphate 100ppm + Citric acid 150ppm +8-Hydroxyquinoline sulphate 250ppm



**Figure 8: Vase life of bird-of-paradise cut flowers as influenced by holding solutions**

**Table 15: Cost effectiveness of usage of floral preservatives in Experiment-I for enhancing the vase life of bird-of-paradise cut flowers**

Treatments	Additional vase life (Days)	Additional cost (Rupees)	Additional vase life : Additional cost
P <sub>0</sub>	-	-	-
P <sub>1</sub>	4	2	2
P <sub>2</sub>	6.33	2.5	2.53
P <sub>3</sub>	2.33	3	0.78

**P<sub>0</sub>** : No pulsing (Kept in distilled water)

**P<sub>1</sub>** : Pulsing with 5% Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours

**P<sub>2</sub>** : Pulsing with 10% Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours

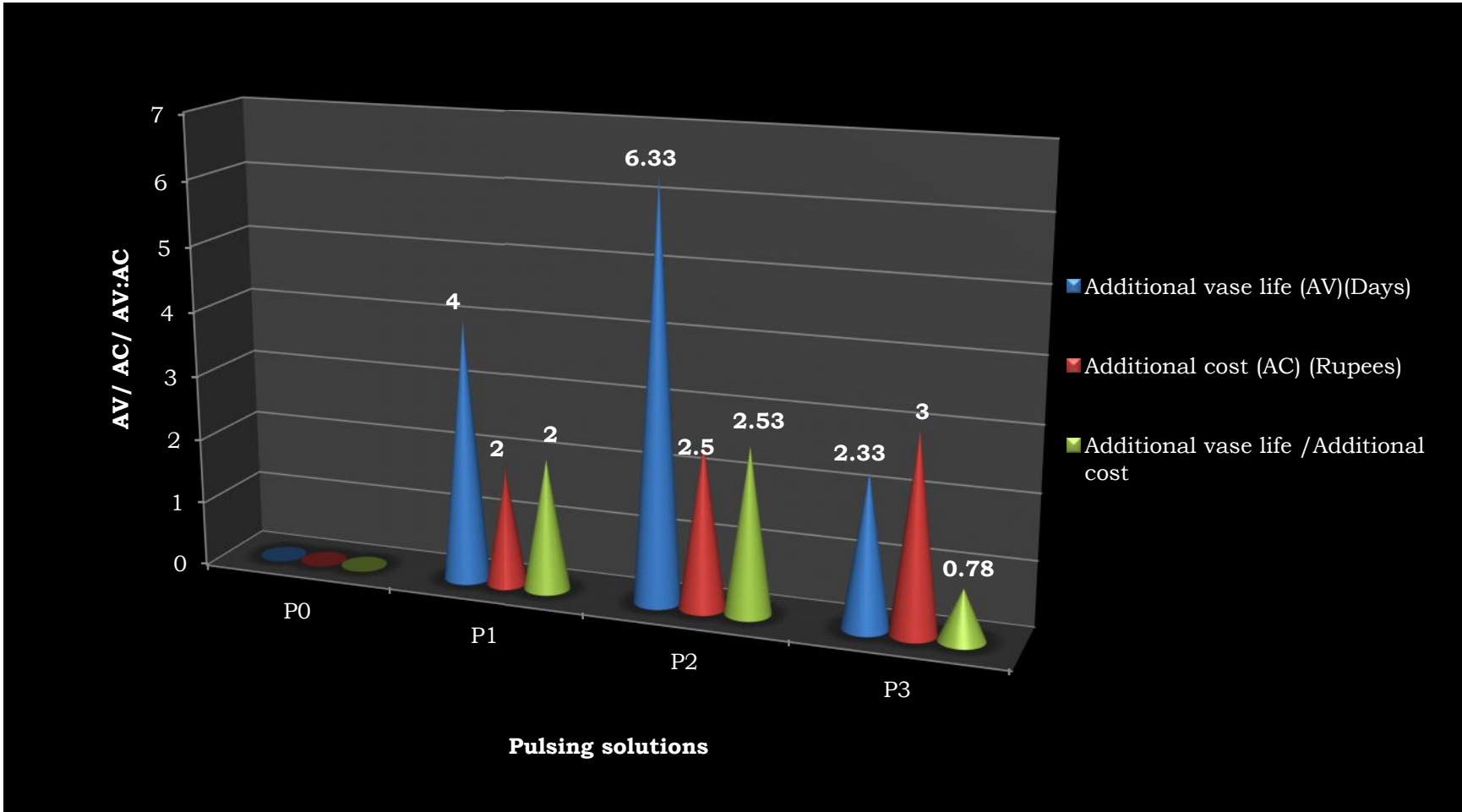
**P<sub>3</sub>** : Pulsing with 15% Sucrose + 200ppm 8HQS + 150ppm Citric acid for 48 hours

The results clearly indicates that, the cut flowers held in the holding solution T<sub>17</sub> (10% sucrose + silver thiosulphate 100ppm + citric acid 150ppm + 8HQS 250ppm) had maximum vase life (15.33 days) whereas, the minimum (9.00 days) was recorded in flowers held in distilled water.

#### **4.3 Cost effectiveness of usage of floral preservatives in Experiment-I for enhancing the vase life of bird-of-paradise cut flowers**

The data pertaining to the cost effectiveness of floral preservatives used in Experiment I for enhancing the vase life of bird-of-paradise cut flowers were depicted in Table15 and Figure 9.

The highest additional vase life to additional cost ratio was obtained in the bird-of-paradise cut flowers pulsed with P<sub>2</sub> (10 % sucrose + 150ppm citric acid + 200ppm 8HQS for 48 hours) (2.53), whereas, the lowest was obtained in the flowers held in P<sub>3</sub> (15 % sucrose + 150ppm citric acid + 200ppm 8HQS for 48 hours) (0.78).



**Figure 9: Cost effectiveness of usage of floral preservatives in Experiment-I for enhancing the vase life of bird-of-paradise cut flowers**



*DISCUSSION*

## **V. DISCUSSION**

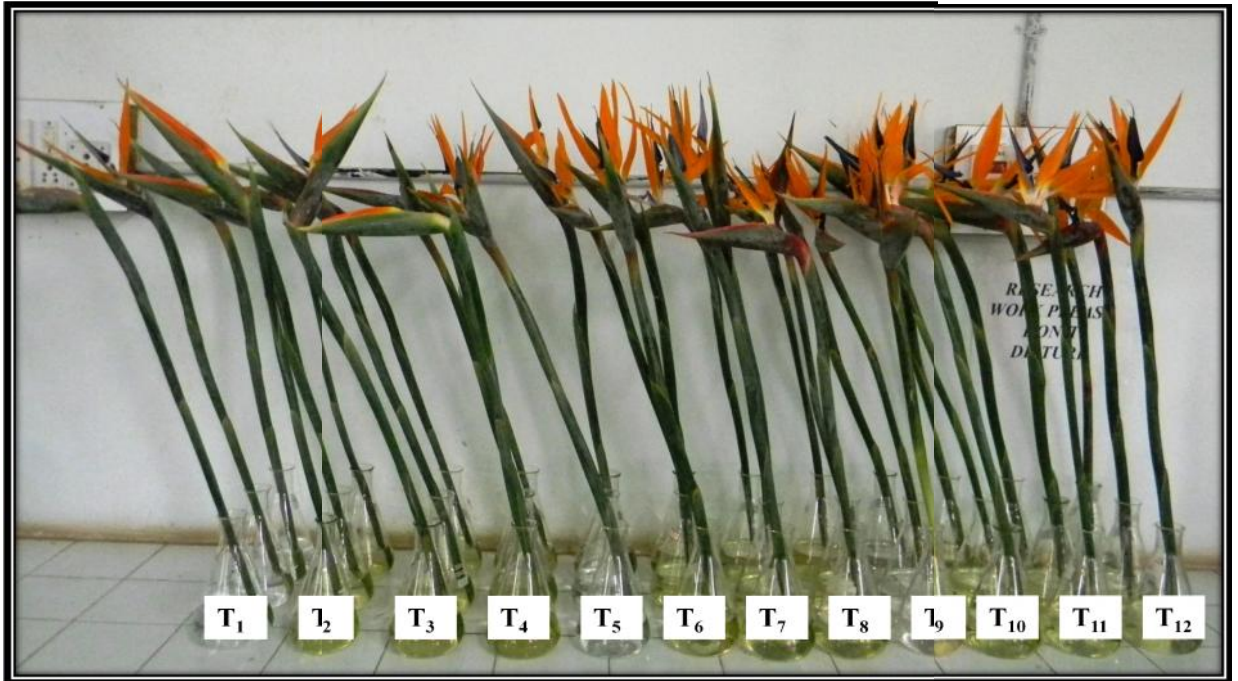
Bird-of-paradise (*Strelitzia reginae* Ait) is an important subtropical cut flower, which is becoming popular because of its unique inflorescence of brilliant orange with purple colour. Bird-of-paradise, matching to the international standards, are being grown in different parts of India. It is one of the most important cut flower in the international market, hence maintenance of quality during post harvest life is of utmost importance for an exporter. There are different methods of maintaining the quality of the cut flowers. Practices such as harvesting at proper stage, pulsing and using of holding solutions are some among them. Vase solution generally contains water to maintain turgidity, chemical to lower the pH, sugar as a source of energy, germicide to inhibit the growth of microorganisms and an ethylene inhibitor. The present studies were undertaken involving the stages of harvest of the flowers, pulsing and holding solutions with the main objective of knowing their effects on post harvest behaviour of bird-of-paradise cut flowers.

The results obtained in these experiments on the post harvest longevity of bird-of-paradise cut flowers are critically discussed under the following headings.

### **5.1 Experiment-I: Evaluation of the best stage of harvest and pulsing solution on the vase life of bird-of-paradise cut flower**

#### **5.1.1 Water relations**

Water relations is very important for any cut flower held in the pulsing solution, because of the reason that uptake of water, loss of water, ratio between them and water balance determine the vase life. All these traits are correlated with each other. Higher uptake of water, lower



**Plate 2: Bird-of-paradise cut flowers kept for pulsing**



**Plate 3: Bird-of-paradise cut flowers transferred to distilled water after 48 hours of pulsing**

loss of water, higher ratio between them and better water balance is required for maintaining longer vase life.

#### **5.1.1.1 Uptake of water (g/cut flower)**

The most important pre requisite for long life of any cut flower is the capacity to absorb water, undisturbedly (Aarts, 1957). The cut flowers of bird-of-paradise harvested at one floret open stage (S<sub>2</sub>) recorded significantly higher uptake of water, not only at different periods of vase life but also during the entire period of vase life. In general, it has significantly resulted in higher cumulative uptake of water (59.00 g/cut flower). While the lowest cumulative water uptake (41.63 g/cut flower) was found to be associated with the cut flowers harvested two days prior to commercial stage of harvest (S<sub>1</sub>). This may be due to the higher conductive capacity of the tissue in the flowers harvested at S<sub>2</sub>, where the water conducting tissues are fully developed, compared to the flowers harvested at S<sub>1</sub>, since the tissues are less developed. The results are in conformity with the results obtained by Gopinath (1996), who reported a similar trend in the cut flowers of gladiolus.

The cut flower of bird-of-paradise pulsed for 48 hours with 10 per cent sucrose + 200ppm 8HQS + 150ppm citric acid (P<sub>2</sub>) recorded significantly higher uptake of water during different intervals and in the cumulative water uptake (70.78 g/cut flower) whereas, the lowest was recorded in the flowers held in distilled water (P<sub>0</sub>) (29.00 g/cut flower). The results obtained is a natural phenomenon as gradient existed between the sap of the cut flower and the pulsing solution. 8HQS and citric acid being a germicide and acidifier, prevents microbial growth and blockage of vascular tissue, thus increasing the water uptake. These results are in conformity with reports of Phanindra (1996) and Ali (2008) in gladiolus and daffodil crops, respectively.

The interaction effect of harvesting the flowers at one floret open stage and pulsing with 10 per cent sucrose + 150ppm citric acid + 200ppm 8HQS (S<sub>2</sub>P<sub>2</sub>) resulted in the highest cumulative water uptake (87.00 g/cut flower) and the flowers harvested two days prior to commercial stage of harvest and held in distilled water (S<sub>1</sub>P<sub>0</sub>) recorded lower uptake of water (25.83 g/cut flower).

#### **5.1.1.2 Loss of water (g/cut flower)**

Loss of water is as important as uptake of water for any cut flower; minimal loss of water in relation to higher uptake of water favours extending the vase life of a cut flower.

The results revealed that, the bird-of-paradise cut flower harvested at commercial stage of harvest (S<sub>2</sub>) recorded highest transpiration loss of water as well as, cumulative loss (64.39 g/cut flower) whereas, the flowers harvested two days prior to commercial stage of harvest (S<sub>1</sub>) recorded the lowest (49.96 g/cut flower). Among the different pulsing solutions used, the cut flowers kept in 10 per cent sucrose + 200ppm 8HQS + 150ppm citric acid recorded the highest water loss (75.62 g/cut flower) and the lowest water loss was observed in the flowers kept without pulsing (37.49 g/cut flower).

Similar was the trend with respect to uptake of water. The trend gave an indication that the level of water loss depends on the level of uptake of water by the cut flower during the vase life. It was noticed that the treatments which experienced greater loss of water had recorded higher uptake of water. This may be due to higher water content triggering high O<sub>2</sub> level of metabolic activity in the cut flowers and vice versa. The results have indicated positive correlation between loss of water and uptake of water by the cut flowers.

The results obtained could be justified by the effect of sucrose on maintaining cell turgidity due to promoted uptake of water which in turn resulted in greater loss of water (Murali, 1990).

Among the interaction effect, the flowers harvested at commercial stage of harvest and pulsed with 10 per cent sucrose + 200ppm 8HQS + 150ppm citric acid for 48 hours (S<sub>2</sub>P<sub>0</sub>) recorded the highest cumulative water loss (90.23 g/cut flower) and the lowest was found in the flowers harvested two days prior to commercial stage of harvest and held in distilled water without pulsing (S<sub>1</sub>P<sub>0</sub>) (35.70 g/cut flower). The water loss was less in S<sub>1</sub>P<sub>0</sub> due to the less development of the water conducting tissues and the absence of gradient between the flower sap and the distilled water.

#### **5.1.1.3 Ratio between uptake of water and loss of water.**

Ratio between uptake of water and loss of water is computed to know the relationship between the two. Generally higher uptake of water and lower loss of water by the cut flowers give the higher ratio.

The results indicated that, the cut flowers of bird-of-paradise harvested at commercial stage of harvest had higher ratio during different periods and cumulative ratio (0.90). While the cut flowers harvested two days prior to commercial stage of harvest recorded the lowest (0.82), giving an indication that the flowers at commercial stage tend to maintain more uptake of water compared to other two stages.

The cut flowers pulsed with 10 per cent sucrose + 200ppm 8HQS + 150ppm citric acid for 48 hours recorded the highest ratio between water uptake and water loss during different periods, which resulted in higher cumulative ratio (0.93) and the minimum was recorded in control (0.77). Sucrose with its capacity as a regulator of osmotic potential might have

resulted in obtaining higher ratio between cumulative uptake of water and cumulative loss of water (Chandrashekar, 1999).

The interaction effect of cut flowers harvested at commercial stage of harvest and pulsed with 10 per cent sucrose + 200ppm 8HQS + 150ppm citric acid for 48 hours showed highest cumulative ratio (0.96) whereas, the lowest loss of water was recorded in the flowers harvested two days prior to commercial stage of harvest and held in distilled water (0.72). The lower ratio is due to the higher loss of water and lesser water uptake from the flowers.

#### **5.1.1.4 Water balance**

Water balance in the cut flowers held in vase solution is an indicator to decide about the longevity of the cut flower in the vase. Increased uptake of water with decreased loss of water and even decreased uptake of water and minimal loss of water results in greater water balance.

Bird-of-paradise flowers harvested at commercial stage of harvest (S<sub>2</sub>) resulted in maximum cumulative water balance (-5.39 g/cut flower) whereas, the minimum was observed in the flowers harvested two days prior to commercial stage of harvest (S<sub>1</sub>) (-8.33 g/cut flower). The results infer that, the water uptake is less and the water loss is more in the flowers harvested earlier than the commercial stage.

Among the different pulsing solutions used, the cut flowers of bird-of-paradise that were pulsed with 10 per cent sucrose + 200ppm 8HQS + 150ppm citric acid recorded higher cumulative water balance (-4.84 g/cut flower) and the flowers held in distilled water without pulsing (P<sub>0</sub>) recorded minimum (-8.49 g/cut flower). Lower uptake of water in view of no pulsing was reported by Harinatha Reddy (2005) in bird-of-paradise cut flower.

The interaction effect of stage of harvest and pulsing solution on water balance was found highest in S<sub>2</sub>P<sub>2</sub> (Flowers harvested at commercial stage and pulsed with 10 per cent sucrose + 200ppm 8HQS + 150ppm citric acid for 48 hours)(-3.23 g/cut flower) whereas, the lowest was recorded in the flowers harvested two days prior to commercial stage of harvest and held in distilled water without pulsing(S<sub>1</sub>P<sub>0</sub>) (-9.87 g/cut flower).

### **5.1.2 Fresh weight of cut flowers (g)**

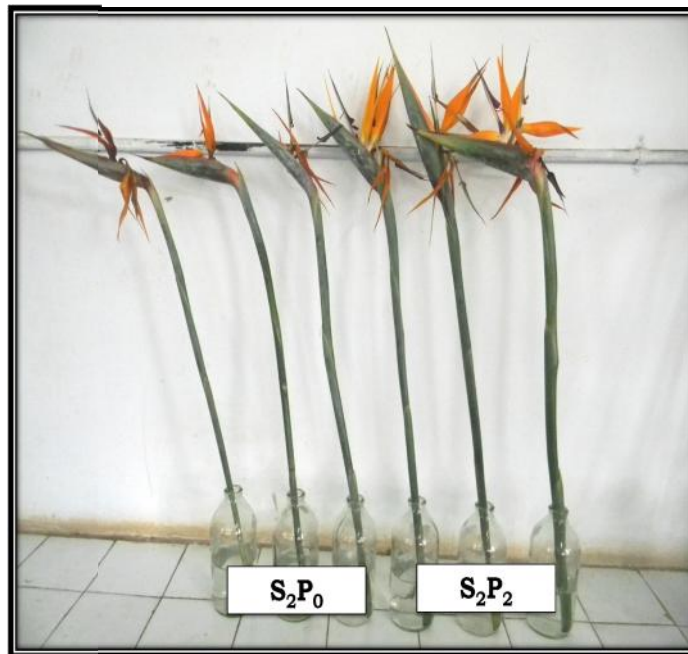
Fresh weight of a cut flower is important for the maintenance of vase life. More the fresh weight of a cut flower, more the longevity due to higher level of accumulated photosynthates in it. However, for the maintenance of vase life, along with the fresh weight of a cut flower, source of energy, water content, germicide and anti senescence agent are also considered important. Fresh weight of bird-of-paradise cut flower showed a declining trend from the beginning till the end of vase life.

The cut flower of bird-of-paradise harvested at commercial stage had maximum fresh weight at different periods till the last day (116.86g) of vase life whereas, the flowers harvested two days prior to commercial stage of harvest recorded the minimum (113.67g). The minimum fresh weight in the flower harvested two days prior to commercial stage of harvest is due to the lesser reducing sugar content, which plays a major role in expansion of floret (Singh *et al.*, 2005).

The results indicated that the bird-of-paradise cut flower pulsed with 10 per cent sucrose + 200ppm 8HQS +150ppm citric acid for 48 hours (P<sub>2</sub>) registered maximum fresh weight during different periods and at the end (117.49g) of the vase life and the minimum was recorded in the flowers held in distilled water (P<sub>0</sub>) (113.51g).



**Plate 4: S<sub>2</sub>P<sub>2</sub> in Experiment-I on 15<sup>th</sup> day**



**Plate 5: S<sub>2</sub>P<sub>0</sub> and S<sub>2</sub>P<sub>2</sub> in Experiment-I on 15<sup>th</sup> day**

Constant maintenance of fresh weight and gradual decrease in fresh weight of cut flower is an important pre requisite for extending the vase life of any cut flower. Sucrose being a respiratory substrate and regulator of osmotic potential might have resulted in higher fresh weight of the cut flower. The results are concomitant with the observations of Varadaraju (2010) in cut flowers of heliconia.

The interaction effect of flowers harvested at commercial stage and pulsed with 10 per cent sucrose + 200ppm 8HQS +150ppm citric acid for 48 hours (S<sub>2</sub>P<sub>2</sub>) also showed maximum fresh weight of the flowers till the end of vase life (119.10g) and the flowers harvested two days prior to commercial stage and held in distilled water recorded the minimum (111.80g).

### **5.1.3 Physiological loss in weight of cut flowers (%)**

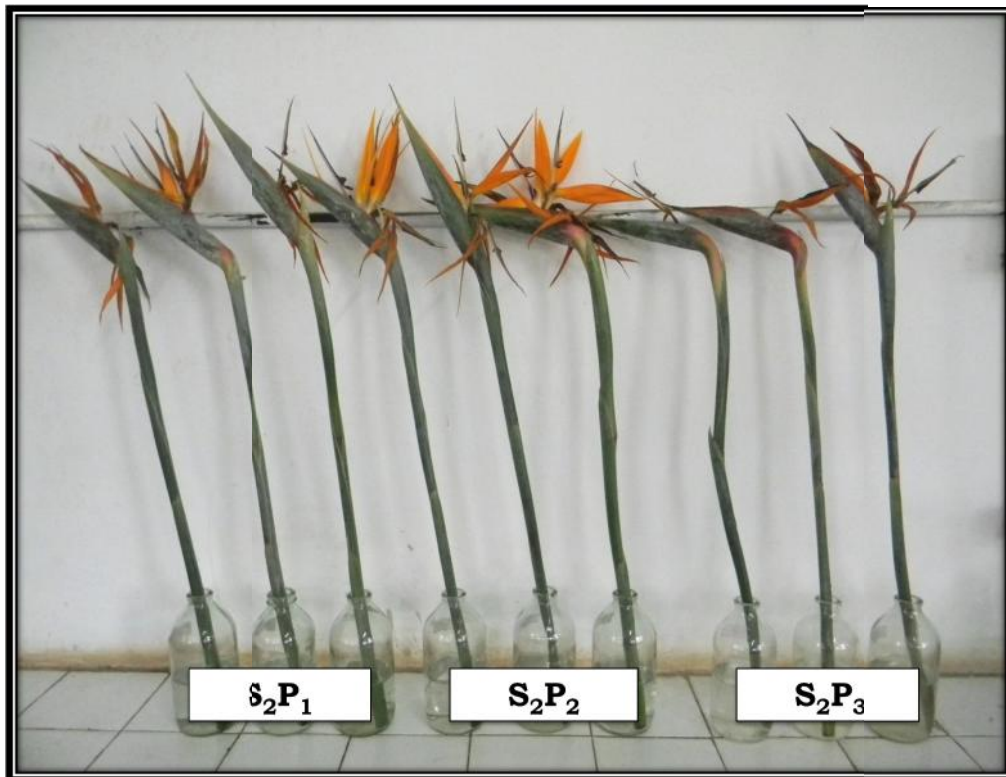
Similar to the fresh weight of a cut flower, physiological loss in weight is also important as this also determines the longevity of cut flowers. Fresh weight and physiological loss in weight are found to be inversely proportional.

The cut flower of bird-of-paradise harvested at commercial stage of harvest showed lesser physiological weight loss during different periods of vase life, which reflected in minimum cumulative physiological loss (4.50%) whereas the flowers harvested at two days prior to commercial stage recorded the maximum physiological loss in weight (7.02%). This may be due to the unopening of the remaining florets and wilting of the flower after the emergence of first floret.

It is clearly evident from the data (table 6) that the cut flowers of bird-of-paradise pulsed with 10 per cent sucrose + 200ppm 8HQS +150ppm citric acid for 48 hours (P<sub>2</sub>) had minimum physiological weight loss (4.02%) compared to the flowers kept in distilled water (7.15%). This



**Plate 6 :  $S_1P_2$ ,  $S_2P_2$  and  $S_3P_2$  in Experiment-I on 15<sup>th</sup> day**



**Plate 7 :  $S_2P_1$ ,  $S_2P_2$  and  $S_2P_3$  in Experiment-I on 15<sup>th</sup> day**

is due to the sucrose in the solution serving as a source of food and maintaining osmotic potential in the flowers (Song *et al.*,1995).

The interaction effect of bird-of-paradise cut flower harvested at commercial stage and pulsed with 10 per cent sucrose + 200ppm 8HQS + 150ppm citric acid for 48 hours (S<sub>2</sub>P<sub>2</sub>) also showed minimum physiological weight loss (2.67%) whereas, the maximum was recorded in the flowers harvested at two days prior to commercial stage of harvest and held in distilled water (8.37%).

#### **5.1.4 Vase life of cut flowers (days)**

Ultimately, in any post harvest studies, it is the vase life that is taken in to account, of course, on the basis of cost economics. Any factor that has influence in extending the vase life of a cut flower is welcome.

The vase life of the flower depends on various factors such as water uptake, reduction in transpiration rate, improved water balance etc.

Maximum vase life of bird-of-paradise cut flower was observed in the flowers harvested at commercial stage (12.83days) whereas the minimum was observed in the flowers harvested two days prior to commercial stage of harvest (10.33days). This is due to the better water relation in the flowers harvested at the commercial stage of harvest (Gopinath, 1996).

The cut flower of bird-of-paradise pulsed with 10 per cent sucrose + 200ppm 8HQS +150ppm citric acid for 48 hours (P<sub>2</sub>) recorded higher vase life (14.11days) compared to the flowers held in distilled water (9.11days). Maximum cumulative water uptake, maximum fresh weight and minimum physiological loss in weight had played their role in influencing the cut flowers to extend their vase life.

The interaction effect of bird-of-paradise cut flowers harvested at commercial stage and pulsed with 10 per cent sucrose + 200ppm 8HQS +150ppm citric acid for 48 hours (S<sub>2</sub>P<sub>2</sub>) had registered highest vase life (16.00days) compared to control (8.67 days)as well as other interactions. The better water relation in the cut flowers harvested at commercial stage and the sucrose supplementing sufficient intracellular carbohydrate reserve ensured maximum vase life (Murali, 1990b).

## **5.2 Experiment-II: Effect of floral preservatives and their concentration in the holding solution on the quality and vase life of bird-of-paradise harvested at commercial stage of harvest**

### **5.2.1 Water relation**

Water relations is very important for any cut flower held in the holding solution, because of the reason that uptake of water, loss of water, ratio between them and water balance determine the vase life. All these traits are correlated with each other. Higher uptake of water, lower loss of water, higher ratio between them and better water balance is required for maintaining longer vase life.

#### **5.2.1.1 Uptake of water (g/cut flower)**

Longer vase life of cut flower is ensured by its water uptake (Aarts, 1957). In the present investigation the uptake of water was significantly influenced by different holding solutions. The cut flower of bird-of-paradise held in a holding solution containing 10% sucrose + silver thiosulphate 100ppm + citric acid 150ppm + 8-HQS 250ppm (T<sub>17</sub>) registered highest water uptake during different periods which reflected in highest cumulative water uptake (80.64 g/cut flower) whereas, the flowers held in distilled water recorded the minimum cumulative uptake of water (26.04 g/cut flower). A gradual declining in the uptake of water

was noticed during the period of vase life. This could be attributed to the rate of metabolic activities taking place in the cut flower. Higher level of metabolic activities in the cut flower might have led to the higher level of water uptake in the initial stages.

Presence of sucrose in the holding solution created difference in water potential between the flower sap and the holding solutions, thus, had led to the more uptake of water. Microorganisms are considered to be one of the main cause for reduced uptake of water by cut flowers, as a germicide 8-HQS is used in the holding solution, hence, microbial growth and resistance to water flow to the stem is reduced (Aarts, 1957; Burdett, 1970).

#### **5.2.1.2 Loss of water (g/cut flower)**

Similar to the uptake of water, the treatment involving , holding the cut flower of bird-of-paradise in the solution containing 10% sucrose + silver thiosulphate 100ppm + citric acid 150ppm + 8HQS 250ppm (T<sub>17</sub>) registered significantly maximum cumulative loss of water (82.14 g/cut flower) compared to control (35.04 g/cut flower). The maximum cumulative loss of water might be due to the effect of sucrose and 8HQS in taking up maximum amount of water. Once the cells become turgid, the condition is generally favourable for the stomata to open. This factor might have acted upon in effecting the maximum cumulative loss of water (Aarts, 1957).

It also found interesting to note that, the loss of water increases by increase in water uptake, thereby indicating that there exists a positive correlation between the water uptake and water loss.

#### **5.2.1.3 Uptake of water : loss of water**

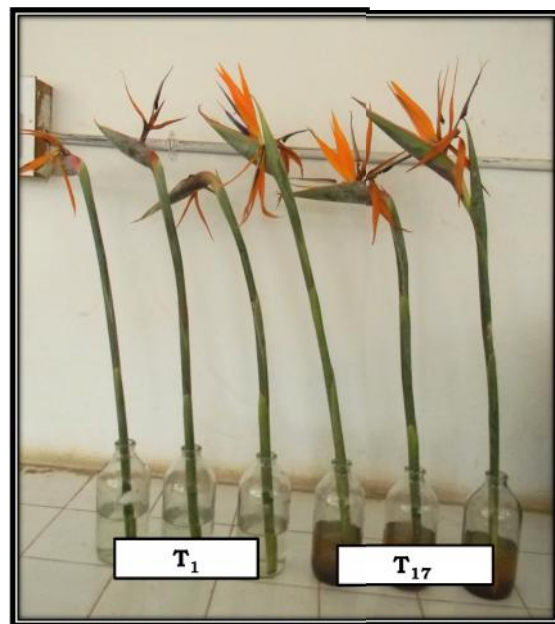
In the present investigation, it has been demonstrated that the bird-of-paradise cut flower held in a solution containing 10% sucrose +



**Plate 8 : General view of Experiment-II**



**Plate 9 : T<sub>17</sub> in Experiment-II  
on 15<sup>th</sup> day**



**Plate 10 : T<sub>1</sub> and T<sub>17</sub> in  
Experiment-II  
on 15<sup>th</sup> day**

silverthiosulphate 100ppm + citric acid 150ppm + 8HQS 250ppm (T<sub>17</sub>) recorded the maximum ratio between the cumulative uptake of water and cumulative loss of water(0.98) and the minimum was recorded in the flowers held in distilled water (T<sub>0</sub>) (0.74). The present findings are in agreement with the observation of Halevy and Mayak (1974b) who has reported that 8HQS and citric acid tend to the closer of stomata and thereby reduced the loss of water occurring in the form of transpiration, thus, leading to higher ratio between the cumulative uptake of water and cumulative loss of water.

#### **5.2.1.4 Water balance (g/cut flower)**

The water balance is a major factor influencing the quality and longevity of cut flowers (Aarts 1957; Mayak *et al.*, 1974).

All the treatments recorded negative water balance. Similar results were reported by Vandoorn (1997). The cut flower of bird-of-paradise held in holding solution containing 10 per cent sucrose + silver thiosulphate 100ppm + citric acid 150ppm +250ppm 8HQS recorded the maximum water balance(-1.50g/cut flower), whereas the flowers held in distilled water recorded the minimum (-9.00 g/cut flower).

The maximum cumulative uptake of water as supported by the maximum ratio between the cumulative uptake of water and the cumulative loss of water must have resulted in maximum water balance as noticed in the treatment mentioned above.

#### **5.2.2 Fresh weight of cut flowers (g)**

Fresh weight of the cut flower is important from the point of maintenance of vase life.

The cut flower of bird-of-paradise held in a solution containing 10 per cent sucrose + silver thiosulphate 100ppm + citric acid 150ppm

+250ppm 8HQS recorded higher fresh weight (121.50g) at the end of vase life, whereas, the lowest fresh weight was recorded in cut flowers held in distilled water (control) (112.00g).

This effect could be attributed to the role of sucrose as source of energy, in addition to this; antimicrobial and acidifying nature of both 8HQS and citric acid might have resulted in maintaining the maximum fresh weight of the cut flower (Coorts *et al.*, 1965; Halevy *et al.*, 1978)

### **5.2.3 Physiological loss in weight of cut flowers (%)**

The cut flowers of bird-of-paradise held in a solution containing 10 per cent sucrose + silver thiosulphate 100ppm + citric acid 150ppm +250ppm 8HQS recorded the minimum percentage of cumulative physiological loss in weight (1.23%) during the period of vase life compared to the maximum physiological loss in weight (7.65%) recorded in flowers held in distilled water .

The maximum fresh weight of cut flowers till the end of the vase life registered by the same treatment could speak in favour of the results obtained with respect to physiological loss in weight of cut flowers during the same period. Probably sucrose had played a major role in minimizing the physiological loss in weight of the cut flowers although, 8HQS and citric acid also had a minor role to play in the maintenance of per cent physiological loss in weight (Varadaraju, 2010).

### **5.2.4 Vase life of cut flowers (days)**

Significantly longer vase life (15.33days) was found to be associated with the cut flower of bird-of-paradise held in a solution containing 10 per cent sucrose + silver thiosulphate 100ppm + citric acid 150ppm + 250ppm 8-HQS compared to the shorter vase life (9.00 days) observed in the cut flowers held in distilled water.

Citric acid and 8-HQS serving as acidifying agents might have prevented the blockage of xylem vessels in the cut flowers stems (Bhaskar *et al.*, 1999). Silver thiosulphate as a ethylene inhibitor has played a role in increasing the vase life (Veen, 1983). In addition to these, sucrose which is a respiratory substrate might have extended the vase life (Halevy *et al.*, 1978). The results obtained could also take support from maximum uptake of water, ratio between water uptake and water loss, fresh weight and minimum physiological loss in weight of cut flower which are associated with the same treatment.

### **5.3 Cost effectiveness of usage of floral preservatives in Experiment-I for enhancing the vase life of bird-of-paradise cut flowers**

Generally adoption of any results depends on the cost effectiveness.

The best results obtained supported by cost effectiveness will certainly have practical value. Hence, the treatments were subject to economics analysis (Varadaraju, 2010) to arrive at the conclusion. The treatment involving pulsing with 10 per cent sucrose + 200ppm 8-HQS +150ppm citric acid for 48 hours produced the maximum additional vase life to additional cost ratio (2.53) proving that it was the best treatment for enhancing the vase life of Bird of Paradise up to 16.00 days.



*SUMMARY AND CONCLUSION*

## VI. SUMMARY AND CONCLUSION

Studies were undertaken to extend the post harvest life of bird-of-paradise (*Strelitzia reginae* Ait.) cut flowers by employing techniques such as stage of harvest, pulsing and holding solution in the Department of Horticulture, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru during 2010-11.

The salient findings of the research conducted are summarised below.

### **6.1 Experiment-I: Evaluation of the best stage of harvest and pulsing solution on the vase life of bird-of-paradise**

The bird-of-paradise cut flower harvested at commercial stage (one floret open stage) recorded the maximum values for cumulative uptake of water (59.00 g/cut flower), cumulative loss of water(64.39 g/cut flower), cumulative ratio of uptake of water and loss of water(0.90 g/cut flower), cumulative water balance (-5.39 g/cut flower), fresh weight(116.86g), minimum physiological loss in weight(4.50%) and longest vase life (12.83days) whereas, the minimum cumulative uptake of water (41.63 g/cut flower), cumulative loss of water(49.96 g/cut flower), cumulative ratio of uptake of water and loss of water(0.82 g/cut flower), cumulative water balance(-8.33 g/cut flower), fresh weight(113.67g), maximum physiological loss in weight(7.02%) and shortest vase life (10.33days) were observed in the bird-of-paradise cut flower harvested two days prior to commercial stage.

Among the different pulsing solutions used, the bird-of-paradise cut flower pulsed with 10 per cent sucrose + 150ppm citric acid + 200ppm 8HQS for 48 hours recorded the maximum values for

cumulative uptake of water (70.78 g/cut flower), cumulative loss of water (75.62 g/cut flower), cumulative ratio of uptake of water and loss of water (0.93 g/cut flower), cumulative water balance (-4.84 g/cut flower), fresh weight (117.49g), minimum physiological loss in weight (4.02%) and longest vase life (14.11days) whereas, the minimum cumulative uptake of water (29.00 g/cut flower), cumulative loss of water (37.49 g/cut flower), cumulative ratio of uptake of water and loss of water (0.77 g/cut flower), cumulative water balance (-8.49 g/cut flower), fresh weight (113.51g), maximum physiological loss in weight (7.15%) and shortest vase life (9.11days) was observed in bird-of-paradise cut flower held in distilled water without pulsing.

In the interaction effect of stage of harvest and pulsing solutions, the cut flower of bird-of-paradise harvested at commercial stage and pulsed with 10 per cent sucrose + 150ppm citric acid + 200ppm 8HQS for 48 hours recorded the maximum values for cumulative uptake of water (87.00 g/cut flower), cumulative loss of water (90.23 g/cut flower), cumulative ratio of uptake of water and loss of water (0.96 g/cut flower), cumulative water balance (-3.23 g/cut flower), fresh weight (119.10g), minimum physiological loss in weight (2.67%) and longest vase life (16.00days) whereas, the minimum cumulative uptake of water (25.83 g/cut flower), cumulative loss of water (35.70 g/cut flower), cumulative ratio of uptake of water and loss of water (0.72 g/cut flower), cumulative water balance (-9.87 g/cut flower), fresh weight (111.80g), maximum physiological loss in weight (8.37%) and shortest vase life (8.67days) were observed in the bird-of-paradise cut flower harvested two days prior to commercial stage and held in distilled water without pulsing.

## **6.2 Experiment-II: Effect of floral preservatives and their concentration in the holding solution on the quality and vase life of bird-of-paradise harvested at commercial stage of harvest**

The bird-of-paradise cut flower harvested at commercial stage of harvest and held in a holding solution containing 10 per cent sucrose + silver thiosulphate 100ppm + citric acid 150ppm + 250ppm 8HQS recorded the maximum values for cumulative uptake of water (80.64 g/cut flower), cumulative loss of water (82.14 g/cut flower), cumulative ratio of uptake of water and loss of water (0.98 g/cut flower), cumulative water balance (-1.50 g/cut flower), fresh weight (121.50g), minimum physiological loss in weight (1.23%) and longest vase life (15.33days) whereas, the minimum cumulative uptake of water (26.04 g/cut flower), cumulative loss of water (35.04 g/cut flower), cumulative ratio of uptake of water and loss of water (0.74 g/cut flower), cumulative water balance (-9.00 g/cut flower), fresh weight (112.00g), maximum physiological loss in weight (7.65%) and shortest vase life (9.00days) was observed in the bird-of-paradise cut flower held in distilled water.

## **6.3 Cost effectiveness of usage of floral preservatives in Experiment-I for enhancing the vase life of bird-of-paradise cut flowers**

Considering the additional vase life : additional cost ratio, the cut flower pulsed with 10 per cent sucrose + 150ppm citric acid + 200ppm 8HQS for 48 hours was found to be best for enhancing the vase life which recorded highest additional vase life to additional cost ratio (2.53).

## **Conclusion**

The results of the present investigation revealed that, the cut flowers of bird-of-paradise should be harvested at one floret open stage and should be pulsed with 10 per cent sucrose + 150ppm citric acid + 200ppm 8HQS for 48 hours for better keeping quality and prolonged vase life. Pulsing treatment alone was found to be more beneficial than usage of holding solution as per the vase life and cost effectiveness was considered.

## **Future line of work**

Based on the research findings carried out so far, and including the present investigation, following future line of work is proposed.

1. The influence of different temperature ranges on the keeping quality and vase life of the cut flowers has to be carried out, at ambient and under storage conditions.
2. Studies on the use of organic extracts to extend the post harvest life of bird-of-paradise may be carried out.
3. Studies relating to the influence of different floral preservatives on the microbial load at the cut end of the flower stem may be taken up.



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A horizontal scroll graphic with a black outline and a grey shadow. The scroll is unrolled, showing the word "APPENDICES" in the center. The left end of the scroll is rolled up, and the right end is also rolled up.

*APPENDICES*

## APPENDIX I

Weather data recorded during the experimental period (November 2010 to January 2011)

Month	Temperature (°C)		Relative Humidity (%)
	Maximum	Minimum	
November	26.3	17.7	75
December	25.7	15.2	72
January	27.8	19.7	69.9

## APPENDIX II

### Cost (Rs.) of chemical preservatives and cut flower

Sl. No.	Name of the chemical	Quantity (g)	Cost (Rs.)
1	Sucrose	500	125
2	8-Hydroxy Quinoline Sulphate	25	2000
3	Citric acid	500	204
4	Sodium thiosulphate	500	95
5	Silver nitrate	25	1910
6	Aluminium sulphate	500	155
7	Sodium hypochlorite	1litre	144
8	Price of cut flower	1	15