"EFFECT OF DIFFERENT FLORAL PRESERVATIVES ON POSTHARVEST VASE LIFE OF GYPSOPHILA (*Gypsophila paniculata* L.) Cv. STAR WORLD UNDER AMBIENT CONDITIONS"

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MASTER OF SCIENCE IN HORTICULTURE

(FLORICULTURE AND LANDSCAPE ARCHITECTURE)

DEPARTMENT OF FLORICULTURE AND LANDSCAPE ARCHITECTURE

COLLEGE OF HORTICULTURE, RAJENDRANAGAR - 500 030.

SRI KONDA LAXMAN TELANGANA STATE HORTICULTURAL UNIVERSITY

November, 2020

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By

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THESIS SUBMITTED TO SRI KONDA LAXMAN TELANGANA STATE HORTICULTURAL UNIVERSITY
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November, 2020

DECLARATION

I, **T. SANGEETHA** hereby declare that the thesis entitled **"EFFECT OF DIFFERENT FLORAL PRESERVATIVES ON POSTHARVEST VASE LIFE OF GYPSOPHILA (*Gypsophila paniculata* L.) Cv. STAR WORLD UNDER AMBIENT CONDITIONS"** submitted to Sri Konda Laxman Telangana State Horticultural University, Mulugu, Siddipet, for the degree of Master of Science in Horticulture (Floriculture and Landscape Architecture) is the result of original research work done by me. I declare that no material contained in the thesis has been published earlier in any manner.

Place: Rajendranagar, Hyderabad. **Name:** TALARI SANGEETHA

Date: 16 Nov, 2020. **I.D. No:** RHM/18-23

CERTIFICATE

Ms. TALARI SANGEETHA has satisfactorily prosecuted the course of research and that the thesis entitled **"EFFECT OF DIFFERENT FLORAL PRESERVATIVES ON POSTHARVEST VASE LIFE OF GYPSOPHILA (*Gypsophila paniculata* L.) Cv. STAR WORLD UNDER AMBIENT CONDITIONS"** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination.

I certify that neither the thesis nor its part there of has been previously submitted by her for a degree of any University.

Place: Rajendranagar, Hyderabad. **(Dr. D. LAKSHMINARAYANA)**

Date: 16 Nov, 2020 **Chairman**

CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF DIFFERENT FLORAL PRESERVATIVES ON POSTHARVEST VASE LIFE OF GYPSOPHILA (*Gypsophila paniculata* L.) Cv. STAR WORLD UNDER AMBIENT CONDITIONS"** submitted in partial fulfilment of the requirements for the degree of Master of Science in Horticulture (Floriculture and Landscape Architecture) of Sri Konda Laxman Telangana State Horticultural University, Mulugu, Siddipet, is a record of the bonafide research work carried out by **Ms. TALARI SANGEETHA** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance received during the course of the investigations have been duly acknowledged by the authors of the thesis.

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(TALARI SANGEETHA)

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LIST OF SYMBOLS AND ABBREVIATIONS

%	: Per cent
@	: at the rate of
/	: Per
±	: plus or minus
º C	: Degree Centigrade
BC	: Benefit cost ratio
CD	: Critical difference
CRD	: Completely Randomized Design
Cv.	: Cultivar
DNA	: Deoxyribonucleic acid
et al	: et alia (and others)
etc.	: Etctera
e.g.	: Example
F	: Flower
Fig.	: Figure
g	: Gram
g $flower^{-1}$	: Gram per flower
g l^{-1}	: Gram per liter
ha	: Hactare
Hrs.	: hours
i.e	: that is: which is to say; in others
IPCN	: Index to Plant Chromosome Numbe
Kg	: Kilogram
Km	: Kilometer
l	: Liter

mM	: milli moles
mm	: Millimeters
Max.	: Maximum
Min.	: Minimum
mg	: Milli gram
ml	: Milli liter
MT	: Metric tons
No.	: Number
nm	: Namometer
NS	: Non significant
ppm	: parts per million
ODVS	: optical density of vase solution
PCW	: physiological change in weight
RH	: Relative Humidity
ROS	: Relative oxygen species
RWC	: Relative water content
SE. (m) ±	: Standard error of mean
Sig.	: Significant
T	: Treatment
TLW	: Transpirational loss of water
Viz.,	: Namely
WU	: Water uptake
WB	: Water balance
8-HQS	: 8- Hdroxy quinoline sulphate
$Ca(OCl)_2$	: Calcium hypochlorite
AA	: Ascorbic acid
$CaCl_2$	: Calcium chloride

SH	: Sodium hypochlorite
KMS	: Potassium metabisulfate
SU	: Sucrose
SKLTSHU	: Sri Konda Laxman Telangana State Horticultural university

Name of the author	: **TALARI SANGEETHA**
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ABSTRACT

The present investigation entitled “Effect of different floral preservatives on postharvest vase life of gypsophila (*Gypsophila paniculata* L.) Cv. Star World under ambient conditions” was carried out in the Department of Floriculture and Landscape Architecture Laboratory, College of Horticulture, Rajendranagar, Hyderabad during 2019-2020.

In experiment I, effect of sucrose and biocides on postharvest vase life of gypsophila was studied and the results revealed that, among all treatments T_9 (sucrose @ 2 % plus 8-HQS @ 200 ppm) recorded the best figures in majority of the parameters *viz*., water uptake (27.42 g flower^{-1}), transpirational loss of water (22.22 g flower^{-1}), vase life (15.5 days), relative water content (96.38 %), fresh weight (15.9 g flower^{-1}), dry weight (9.4 g flower^{-1}) and water uptake to water loss ratio (1.276) over other treatments and the same treatment registered the lowest optical density of vase solution (0.045 nm) and physiological change in weight (0.82 %) as compared to other treatments, whereas higher water balance was recorded with T_8 (sucrose @ 2 % plus 8-HQS @ 100 ppm) (5.24 g flower^{-1}) rather than other treatments.

In the experiment, studies on the effect of sucrose and antioxidants on postharvest vase life of gypsophila, T_{11} (sucrose @ 2 % plus KMS @ 200 ppm) was shown maximum for most of the parameters *i.e.*, water uptake (31.42 g flower^{-1}), transpirational loss of water (35.02 g flower^{-1}), vase life (16.83 days), relative water content (103.14 %), fresh weight (16.8 g flower^{-1}), dry weight (8.7 g flower^{-1}) and water uptake to water loss ratio (1.045) and lowest for optical density of vase solution (0.044 nm) and physiological change in weight (0.82 %) over other treatments, while highest water balance (0.66 g flower^{-1}) was recorded in T_1 (sucrose @ 2 %) as compared to rest of the treatments.

Third experiment was conducted by taking best holding treatment solution combinations of I and II experiments, among the treatments, T_1 (sucrose @ 2 % + 8HQS @ 200 ppm + KMS @ 200 ppm) registered maximum water uptake (27.76 g flower^{-1}), transpirational loss of water (28.90 g flower^{-1}), vase life (16.98 days), relative water content (100.23 %), fresh weight (17.03 g flower^{-1}), dry weight (9.5 g flower^{-1}) and water uptake to water loss ratio (10.95) and minimum optical density of vase solution (0.077 nm) and physiological change in weight (2.60 %). However higher water balance was recorded in T_3 (sucrose 2 % + 8HQS 100 ppm + KMS 200 ppm) (-0.42g flower^{-1}) over other treatments.

Chapter - I

INTRODUCTION

Gypsophila (*Gypsophila paniculata* L.) is a species of flowering plant in the family Caryophyllaceae and is a native to Central and Eastern Europe. It is mostly grown in Eurasia, Africa, Australia, Turkey and Pacific Island. Turkey has high diversity of Gypsophila taxa, with about 35 endemic species (Korkmaz *et al*., 2012). Gypsophila has a diploid chromosome number of 2n = 34 which is mostly reported, although there are also isolated reports of 2n = 26 and 2n = 68 (St. Louis and Missouri, 2014).

Gypsophila is oftenly grown as ornamental plant in garden and is considered as valuable cut flower in floriculture industry, to add as a filler to flower bouquets. In folklore medicines, it was used as remedy for the coughs, colds and the ailments of the upper respiratory tract. Saponins extracted from *G. paniculata* are used as a source of many products like cleaning chemicals, film emulsions and as an ingredient of fire extinguishers (Rehman, 2002).

Gypsophila is an efficient biological control of nematodes that transmit grapevine fan leaf virus (Pensec *et al*., 2013). Extract from Gypsophila roots have been used as a gold polish and fabric softener and also been used to prepare foods such as herbal cheese and ice cream (Korkmaz and Ozcelik, 2011). Crude extracts from Gypsophila species are cytotoxic to tumour inducing macrophage cell lines and may be useful in fighting cancer (Gevrenova *et al*., 2014).

Gypsophila is an herbaceous perennial, grows up to 1.2 m tall and wide, with mounds of branching stems covered in clouds of tiny white flowers in summer, hence commonly called as baby’s breath. Many species are found on calcium rich soils, including gypsum, which is depicted in the name of the genus "gypsophila" (Walker, 1994).

Nationally flowers are cultivated in an area of 313 ha with a production of 2865 MT (National Horticultural Board, annual report, 2018-19), in that most of the area covered with loose flowers only. Even though gypsophila was in top 10 cut flowers in international market, its cultivated area was negligible in India.

Flowers are preferably harvested in early morning as temperatures are low, consequently plant water content is high and whole day is available for processing the cut flowers. Once the flower is separated from its mother plant, the continuity of water to the flower is disturbed, as water relations play an important role in the postharvest physiology of cut flowers. Hence, postharvest longevity of flowers is of critical importance in determining the value of the crop. Adopting proper postharvest techniques can reduce about 20-40 per cent postharvest loss of cut-flowers (Chandrashekhar and Gopinath, 2004). The extension of cut flower vase life with improved postharvest handling and maintenance has now become commercial and economically important based on scientific principles.

An effective flower food *i.e.*, a preservative solution should contain three basic components to extend the vase life of cut flowers. Sucrose is widely used in floral preservatives, which acts as a food source of respiratory substrate and delays the degradation of proteins, improves the water balance of cut flower. A sugar to provide energy to the flowers, a biocide to kill the microbes and an acidifier to lower the pH of solution, which increases and maintains the uptake of water and nutrients by the flower (Coake, 1997 and Sacalis, 1993). The most ideal floral preservative should maintain water absorption and turgidity in floral tissues. Postharvest metabolic activities like respiration and transpiration are known to influence the vase life of cut flowers (Randhawa and Mukhopadhyay, 1986).

There are several methods to increase the vase life of cut flowers and keep their freshness for longer periods. Cut flowers should be free of any deterioration and is one of the principal entry point for decay organisms. Many chemicals have been used in cut flower vase solution to extend vase life by reduced microbial contamination. The bacteriocides are the most important component in the preservative solutions to control harmful bacteria and help to prevent bacterial embolism (Halevy and Mayak, 1981). A major cause of deterioration in cut flowers is blockage of xylem vessels by microorganisms that accumulate in the vase solution or in the vessels themselves (Danaee *et al*., 2011). For many years, floral preservatives have been identified and are usually included biocides to inhibit bacterial proliferation (Nowak and Rudnicki, 1990).

The 8-HQS is one of the important germicide used in floral industry (Nowak and Rudnicki, 1990) and it acts as an antimicrobial agent (Ketsa *et al*., 1995) which can led to increase water uptake (Reddy *et al*., 1996). High turgidity was achievement by improving water balance by $NaOCl_2$ @ 20 ppm (Van, 1979).

An antioxidant can be defined as “a substance that, when present at low concentrations compared to those of an oxidizable substrate, significantly delays or prevents oxidation of that substrate” (Halliwell, 1990).

Antioxidants either give an electron or a hydrogen atom from their hydroxyl group, thus stabilizing the radical. Some compounds comes under this category are ascorbic acid, tocopherols and polyphenols **(**Marcio *et al*., 2018). Moreover, ascorbic acid is a bacteria growth inhibitor which has been extensively evaluated for protecting cut flowers from physical plugging (Jin *et al*., 2006 and Hatami *et al*., 2010). Calcium Chloride treated cut flowers exhibited more vase life and had the least bacterial colonies population (Ali, 2014).

Looking to the above facts described, the present investigation was designed to have clear appraisal on the effect of different floral preservatives on vase life of gypsophila (*Gypsophila paniculata* L.) Cv. Star World under ambient conditions with the following objectives.

1. To study the effect of biocides on postharvest vase life of gypsophila
2. To study the influence of antioxidants on postharvest vase life of gypsophila
3. To study the effect of combination of best biocides and antioxidants on postharvest vase life of gypsophila

Chapter – II

REVIEW OF LITERATURE

The literature related to the postharvest behaviour of gypsophila and other cut flowers is reviewed in this chapter under the following heads

2. 1. Effect of sucrose and biocides on postharvest vase life of cut flowers.

2. 2. Effect of sucrose and antioxidants on postharvest vase life of cut flowers.

2. 3. Effect of sucrose, biocides and antioxidants on postharvest vase life of cut flowers.

2.1. Effect of sucrose and biocides on postharvest vase life of cut flower

Elgimabi and Ahmed (2009) studied the effect of bacteriocides and sucrose pulsing on vase life of rose cut flower and reported that among the different concentrations of 8-HQS *viz*., 100, 200 and 300 ppm and various levels of sucrose *viz*., 1, 2 and 3 per cent, 8-HQS @ 100 ppm recorded the longer vase life as compared to rest of the treatments.

Hassan (2009) conducted an experiment on influence of 8 Hydroxy quinoline sulphate and sucrose treatments on the postharvest quality of cut flowers of *Strelitzia reginae* and *Hippeastrum vittatum* and found that treatment with 200 ppm of 8HQS plus 10 per cent sucrose, obtained the maximum vase life with quality over other treatments.

Kesta and Jaijam (2010) studies the effect of maleic hydrazide on vase life of cut roses and reported that when the treatment supplied with 8-HQS @ 250 mg l^{-1} plus five per cent sucrose recorded maximum water uptake, fresh weight change and longer vase life and registered minimum water loss as compared to other treatments.

Studies conducted by Abdul (2011) on effect of some preservative solutions on vase life and keeping quality of snapdragon cut flowers and observed that when cut flowers treated with the 8-HQS @ 200 ppm plus two per cent sucrose recorded the best values in terms of water uptake, water balance, fresh weight and vase life which was extended up to 18 days over control.

Ibrahim *et al*. (2011) conducted an experiment on extending postharvest vase life and keeping quality of gerbera cut flowers using some chemical preservatives. They found that treatment of 8-HQS @ 200 ppm recorded significantly maximum water uptake and transpirational loss water during all shelf life periods (3rd, 6th, 9th and 12th). They also opined that when 8-HQS @ 200 ppm supplemented with four per cent sucrose, increased dry weight percentage as well as longevity of cut flower.

Martha *et al.* (2011) studied the effects of calcium on postharvest water status and vase life of *Rosa hybrida* Cv. Grand Gala and reported that treatment of the Calcium chloride @ 10 mM plus Sucrose @ 4 % plus 8-Hydroxy quinoline sulphate @ 300 ppm induced a greater water flow and the most color infiltration through the vascular tissue as well as longer vase life when compared to other treatments.

Khalid and Elhindi (2011) cited that when cut sweet pea flower treated with 1.38 mM 8-HQS plus 58.43nM sucrose recorded the highest values interms of water uptake, water balance, fresh weight of the cut flower stems and vase-life over other treatments

Tekalign *et al*. (2011) conducted an experiment on influence of pulsing biocides and preservative solution treatment on the vase life of cut rose (*Rosa hybrida* L.) Varieties and found that when cut flower stems pulsed with 0.6 ml l^{-1} NaOCl and 0.4 ml l^{-1} 8-HQS recorded maximum vase life (15.50 and 15.08 days respectively) over other treatments.

Abdelkader (2012) studied the postharvest physiology of cut hippeastrum inflorescences and reported that when each stage of bud development stems placed in 8-HQS plus sucrose solution maintained their positive water balance for a longer period, had maximum average solution uptake, fresh weight and longer vase life than those placed in 8-HQS only.

Asrar (2012) conducted an experiment on effects of some preservatives solutions on vase life and keeping quality of snapdragon cut flowers and reported that maximum vase life was recorded in the treatment of 8-HQS @ 200 ppm plus sucrose @ 2 per cent than other treatments.

Elhindi (2012) investigated the effects of postharvest pretreatments and preservative solutions on vase life longevity and flower quality of sweet pea (*Lathyrus odoratus* L.) and found that when cut flowers held in the solution containing sucrose plus 8-hydroxy quinoline sulphate registered higher absorption rate, fresh mass, water balance and vase life over other treatments.

Elgimabi and Sliai (2013) studied the effects of 8-HQS (0, 200, 300 and 400 ppm) and sucrose (0 %, 3 %, 5 % and 7 % w/v) on vase life of Rosa cut flowers Cv. Trigintipetala and reported that treatment of 8-HQS @ 200 ppm plus sucrose @ seven per cent delayed the chlorophyll as well as carbohydrate degradation.

Gul and Taher (2013) cited that when *Narcissus pseudonarcissus* cv. Emperor cut spikes treated with sucrose plus 8-HQS recorded maximum vase life over other treatments.

Mohy and Abdallah (2013) evaluated that among all the treatments, treatment combination of 8-HQS @ 200 ppm plus sucrose @ seven per cent recorded the longer vase life as compared to other treatments.

Hassan and Ali (2014) investigated the effect of 8- Hydroxy quinoline sulphate (8-HQS) on the vase life and postharvest quality of bird of paradise and observed that when flowers treated with 8-HQS @ 250 ppm registered maximum longevity as well as postharvest quality as compared to others.

Galati *et al.* (2015) studied the effect of calcium chloride on postharvest maintenance of *Alstroemeria* cut flowers and found that the preservative solution containing 50 mM l^{-1} of calcium chloride prolonged the vase life over other treatments.

Mohy and Mahmoud (2016) studied the effect of different floral preservatives on carnation cut flowers and reported that the treatment combination of 8-HQS @ 100 ppm plus sucrose three per cent recorded the longer vase life as compared to other treatments.

Malik *et al.* (2016) conducted an experiment on response of cut rose cultivar Cardinal to sucrose and NaOCl concentration and observed that the treatment solution containing 12 per cent sucrose and 15 mg L^{-1} NaOCl recorded significantly minimum petal drop (10 %), early flower opening (4 days), maximum flower size (6.14 cm), minimum flower wilting (15.58 %) and longer vase life (3.39 days) over control treatment.

Studies conducted by Michael *et al.* (2017) on postharvest quality effects of different vase life solutions on cut rose (*Rosa hybrida* L.) and found that the treatment combination of 8HQS plus sucrose recorded maximum vase life (10.5 days) over other treatment combinations.

Chaudhary and Khanal (2018) carried out an experiment on effects of different concentrations of sucrose on vase life of rose Cv. Dutch Hybrid and reported that the highest vase life (19.5 days) was recorded in the treatment of six per cent sucrose over control

Hema *et al*. (2018) concluded that when cut gerbera placed in the vase solution containing sodium hypochlorite 20 ppm recorded significantly maximum vase life (10.6 days), water uptake (8.089 g flower^{-1}), minimum transpiration loss of water (8.405 g flower $^{-1}$), improved water balance (3.753 g flower^{-1}) and reduced fresh weight change of flowers (100.463 %) and least optical density (0.034 nm) than other treatments.

Sweta and Prahlad (2018) studied the effect of vase solution on value addition and vase-life of tinted tuberose Cv. Prajwal and reported that among all chemical treatments calcium hypochlorite @ 750 ppm was best interms of extending vase life followed by sodium hypochlorite @ 750 ppm, benzyl adenine @ 450 ppm and naphthalene acetic acid @ 250 ppm.

Kantharaj *et al*. (2018) investigated that when cut gerbera Cv. Julia placed in vase solution containing sucrose @ 1.0 and 1.5 per cent with sodium hypochlorite (0.3 %) and Benzyl adenine (20 ppm) has been recorded significantly maximum vase life (14.11 and 13.64 days), water uptake (52.57 and 51.92 g flower^{-1}), transpiration loss of water (61.59 and 61.88 g flower^{-1}), relative fresh weight (98.14 and 94.25 %) and also recorded minimum cumulative water balance (-8.72 and -10.22 g flower^{-1}) respectively.

2. 2. Effect of sucrose and antioxidants on postharvest vase life of cut flowers.

An antioxidant can be defined as "a substance that, when present at low concentrations compared to those of an oxidizable substrate, significantly delays or prevents oxidation of that substrate" (Halliwell. 1990). All antioxidants follow one of the seven mechanisms of action, which vary with the type of oxidants: a) sequestration of free radicals from the medium; b) chelation of metallic ions; c) inhibition of free radical producing enzymes; d) activation of endogenous antioxidant enzymes; e) prevention of lipid peroxidation; f) prevention of DNA damage; g) prevention of protein modification and sugar destruction.

Antioxidants either give an electron or a hydrogen atom from their hydroxyl group, thus stabilizing the radical. Some compounds comes under this category are ascorbic acid, tocopherols and polyphenols. **(**Marcio *et al*., 2018)

Soad *et al*. (2011) carried out an experiment on extending postharvest life and keeping quality of gerbera cut flowers using some chemical preservatives and reported that solution of 8-HQS @ 200 ppm or $CaCl_2$ @ 2000 ppm plus four per cent sucrose significantly recorded maximum water uptake and water loss as compared to control.

Cortes (2011) in study investigated the effect of calcium on postharvest vase life of *Rosa hybrid* Cv. Grand Gala. The maximum vase life and fresh weight in the $CaCl_{2\ 10}$ mM plus sucrose 4 per cent plus 8-HQS 300 ppm treatment. This results indicates the effectiveness of calcium in maintaining the integrity of cellular membranes and the importance of 8-HQS as an antibacterial agent, allowing a constant hydration and thus inhibiting vascular occlusion.

Yousif *et al*. (2012) conducted an experiment on effect of sucrose and ascorbic acid on vase life of snapdragon cut spike flowers (*Antirrhinum majus* L.) and reported that 0.5 g l^{-1} of sucrose significantly increased vase life, while ascorbic acid at 150 g l^{-1} significantly increased vase life and fresh weight, but combination of 0.5 g l^{-1} sucrose plus 150 g l^{-1} ascorbic acid increased fresh as well as dry weight over other treatments.

Eshaghdavatgar *et al*. (2013) reported that thyme extract 0.1 ppm in combination with a plus treatment of 3 per cent sucrose plus 4 per cent $CaCl_2$ recorded significant improves vase life of rose cut flower Cv. Dolce vita.

Islam *et al*. (2013) carried out an experiment on influence of sucrose and ascorbic acid on vase life of red ginger and observed that when flowers treated with sucrose @ two per cent plus ascorbic acid @ three ml l^{-1} recorded maximum vase life of (15 days) over control.

Farnaz *et al*. (2015) worked on effects of ascorbic acid and citric acid on vase life of cut lisianthus (*Eustoma grandiflorum* 'Mariachi Blue') and found that highest vase life (17.6 days), relative water content and fresh weight of flowers were recorded for the interaction of ascorbic acid (300 mg L^{-1}) and citric acid (100 mg L^{-1}) which increased 94 per cent vase life as compared to control treatment (9.1 days)

Lakshminarayana (2015) in gladiolus reported that T_{13} treatment (Sucrose 5 % + KMS 200 ppm) recorded maximum water uptake, transpirational loss of water, vase life and minimum optical density of vase solution as compared to other treatments.

Krishnamoorthy *et al*. (2017) conducted an experiment on influence of postharvest treatments shelf life of carnation and reported that among all treatments, T_3 [Boric acid (2 %) + Sucrose (3 %) + Calcium chloride (0.3 %)] recorded higher water uptake (31 g flower^{-1}) and vase life (9 days) as compared to other treatments.

2.3. Effect of sucrose, biocides and antioxidants on postharvest vase life of cut flowers.

Soad *et al*. (2011) carried out an experiment on extending postharvest life and keeping quality of gerbera cut flowers using some chemical preservatives and reported that solution of 8-HQS @ 200 ppm or $CaCl_2$ @ 2000 ppm plus four per cent sucrose significantly recorded maximum water uptake and water loss as compared to control.

Cortes (2011) in study investigated the effect of calcium on postharvest vase life of *Rosa hybrid* Cv. Grand Gala. The maximum vase life and fresh weight in the $CaCl_{2}$ $_{10}$ mM plus sucrose 4 per cent plus 8-HQS 300 ppm treatment. This results indicates the effectiveness of calcium in maintaining the integrity of cellular membranes and the importance of 8-HQS as an antibacterial agent, allowing a constant hydration and thus inhibiting vascular occlusion.

Martha *et al.* (2011) studied the effects of calcium on postharvest water status and vase life of *Rosa hybrida* Cv. Grand Gala and they concluded that treatment combination of $CaCl_2$ plus sucrose plus HQS recorded longer vase life when compared to other treatments.

Samaneh *et al.* (2013) conducted an experiment on effects of ascorbic acid (AA), 8- hydroxyl quinoline sulphate (8-HQS) and sucrose (SU) on cut gerbera and observed that the treatment containing the combination of AA @ 100 mg l^{-1} plus 8-HQS @ 200 mg L^{-1} plus SU @ 30 g L^{-1} registered the highest vase life as compared to other treatments.

Lakshminarayana (2015) carried out an experiment on postharvest vase life of gladiolus Cv. White Prosperity and reported that combination of sucrose 5 % plus STS @ 300 ppm plus KMS @ 200 ppm shown highest water uptake, transpirational loss of water, vase life and least optical density compared to other treatments.

Stigma *et al*. (2018) in tuberose resulted that the highest water uptake and longest vase life (10 days) were recorded in T_7 treatment (3 @ % sucrose + HQS @ 300 ppm + citric acid @ 25 ppm) as compared to other treatments.

Chapter III

MATERIAL AND METHODS

The present investigation entitled "Effect of different floral preservatives on postharvest vase life of gypsophila (*Gypsophila paniculata* L.) Cv. Star World under ambient conditions." was carried out in the Department of Floriculture and Landscape Architecture laboratory, College of Horticulture, Rajendranagar, Hyderabad, Sri Konda Laxman Telangana State Horticultural University during the year 2019-20. The details of location, the material used and the techniques adopted during the period of experimentation are presented in this chapter under the following headings and sub-headings.

3. 1. GEOGRAPHICAL LOCATION

The experimental location, Rajendranagar is situated at an altitude of 542.3 m above mean sea level on 78^0 29' East longitude and 17^0 19'North latitude. Data on weather parameters during the period of investigation recorded at the Agro Climatic Research Centre attached to the Agricultural Research Station, Rajendranagar, Hyderabad are presented in Appendix I.

3. 2. LABORATORY PROFILE

The experimental flowers were held at ambient room temperature 25 ± 2^0C, 40 to 50 per cent relative humidity (RH) under 40W cool white florescent tubes to maintain 12 hours photoperiod.

3.3. MATERIALS

3. 3. 1. Procurement of gypsophila flowers

Flowers of gypsophila (*Gypsophila paniculata* L.) cultivar Star World were obtained from Floricultural Research Station, Rajendranagar which is 5 km away from the College of Horticulture, Rajendranagar, Hyderabad.

3. 3. 2. Description of gypsophila cultivar "Star World"

It is hardy plant. It reaches up to a height of 1-2 meters and bears medium sized white colour panicles and also resistance to pest and diseases.

3. 3. 3. Chemicals used in vase life studies.

All chemicals used in experiment I, II and III were analytical grade, procured from Standard Indian Chemical firms.

3. 4. PREPARATION OF TREATMENT SOLUTIONS

FORMULA:

A) To prepare of one ppm solution: One millilitre (or) one milligram of chemical dissolved in 1000 ml of distilled water gives one ppm.

b) To prepare of one per cent solution: One gram (or) millilitre of chemical dissolved in 100 ml of distilled water gives one per cent.

3. 5. EXPERIMENTAL DETAILS

Three experiments were conducted with sucrose 2 per cent alone and in combination of biocides and antioxidants on gypsophila cut flower with different preservatives.

3. 5. 1. EXPERIMENT – I: EFFECT OF SUCROSE AND BIOCIDES ON POST HARVEST VASE LIFE OF GYPSOPHILA Cv. STAR WORLD UNDER AMBIENT CONDITIONS.

Crop : Gypsophila (*Gypsophila paniculata*)

Cv. : Star World

Design : Completely Randomized Design (CRD)

Number of Treatments : 14

Number of Replications : 03

Number of flower spikes per treatment : 05

Evaluation period : Two days interval

3. 5. 1. 1. TREATMENT DETAILS

T_1: Sucrose @ 2 %

T_2: 8-Hydroxy quinoline sulphate @ 100 ppm (8HQS 100 @ ppm)

T_3: 8-Hydroxy quinoline sulphate @ 200 ppm (8HQS 200 @ ppm)

T_4: Sodium hypochlorite @ 25 ppm (SH @ 25 ppm)

T_5: Sodium hypochlorite @ 50 ppm (SH @ 50 ppm)

T_6: Calcium hypochlorite @ 25 ppm ($Ca(OCl)_2$ @ 25 ppm)

T_7: Calcium hypochlorite @ 50 ppm ($Ca(OCl)_2$ @ 50 ppm)

T_8: Sucrose @ 2 % + 8-Hydroxy quinoline sulphate @ 100 ppm

T_9: Sucrose @ 2 % + 8-Hydroxy quinoline sulphate @ 200 ppm

T_{10}: Sucrose @ 2 % + Sodium hypochlorite @ 25 ppm

T_{11}: Sucrose @ 2 % + Sodium hypochlorite @ 50 ppm

T_{12}: Sucrose @ 2 % + Calcium hypochlorite @ 25 ppm

T_{13}: Sucrose @ 2 % + Calcium hypochlorite @ 50 ppm

T_{14}: Control (Distilled water)

3.5.1.2 Preparation of vase solutions

Sucrose 2 per cent solution was prepared by dissolving 2 g in 100 ml of distilled water similarly sodium hypochlorite (SH) and calcium hypochlorite ($Ca(OCl)_2$) of 25 and 50 ppm were prepared by dissolving calculated chemical in one litre of water, whereas 8-HQS of 100 and 200 ppm were prepared by dissolving 100 and 200 mg in small quantity of ethyl alcohol and volume was made up to one litre (Plate 1).

3.5.2. EXPERIMENT II: EFFECT OF SUCROSE AND ANTIOXIDANTS ON POSTHARVEST VASE LIFE OF GYPSOPHILA Cv. STAR WORLD UNDER AMBIENT CONDITIONS.

Crop **:** Gypsophila (*Gypsophila paniculata*)

Cv. **:** Star World

Design **:** Completely Randomized Design (CRD)

Number of treatments **:** 14

Number of Replications **:** 03

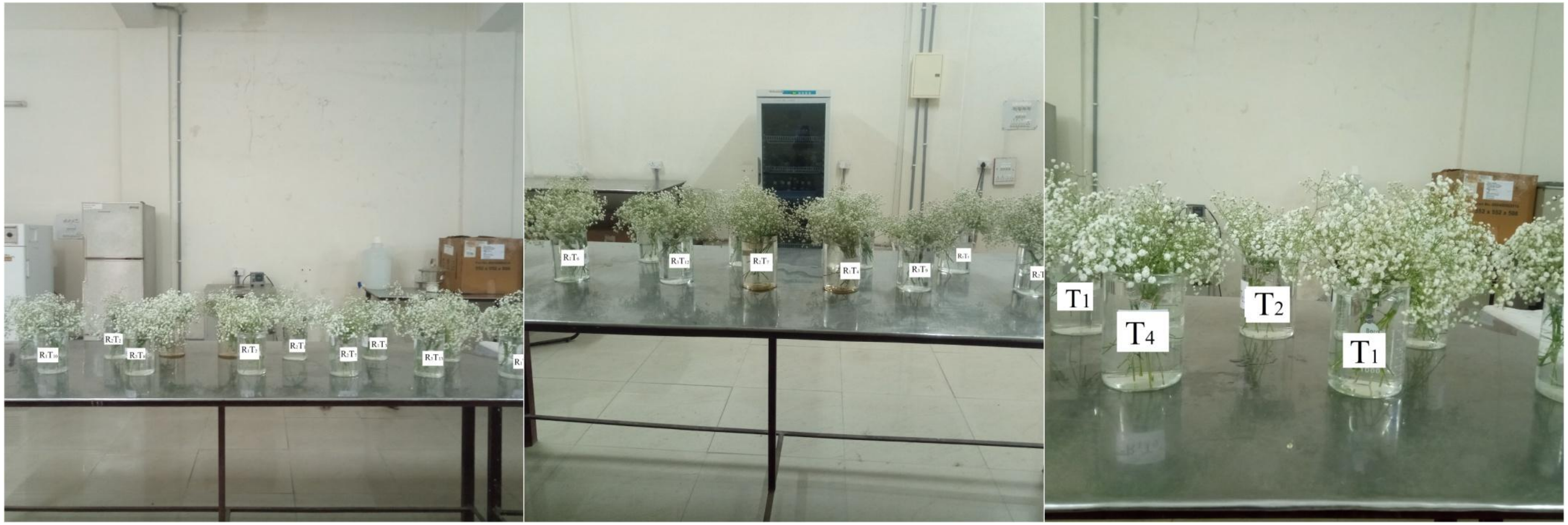

Plate. 1 Over all view of laboratory experiments

Number of flower spikes

per treatment **:** 05

Evaluation period **:** Two days interval

3. 5. 2. 1. TREATMENT DETAILS

T_1: Sucrose @ 2 %

T_2: Ascorbic acid 100 @ ppm (AA @ 100 ppm)

T_3: Ascorbic acid @ 200 ppm (AA @ 200 ppm)

T_4: Potassium meta bisulphite @ 100 ppm (KMS @ 100 ppm)

T_5: Potassium meta bisulphite @ 200 ppm (KMS @ 200 ppm)

T_6: Calcium chloride @ 25 ppm ($CaCl_2$ @ 25 ppm)

T_7: Calcium chloride @ 50 ppm ($CaCl_2$ @ 50 ppm)

T_8: Sucrose @ 2 % + Ascorbic acid @ 100 ppm

T_9: Sucrose @ 2 % + Ascorbic acid @ 200 ppm

T_{10}: Sucrose @ 2 % + Potassium meta bisulphite @ 100 ppm

T_{11}: Sucrose @ 2 % + Potassium meta bisulphite @ 200 ppm

T_{12}: Sucrose @ 2 % + Calcium chloride @ 25 ppm

T_{13}: Sucrose @ 2 % + Calcium chloride @ 50 ppm

T_{14}: Control (Distilled water)

3.5.2.2 Preparation of vase solutions

Sucrose 2 per cent solution was prepared by dissolving 2 g in 100 ml of distilled water similarly ascorbic acid (AA) and potassium meta bisulphite (KMS) of 100 and 200 ppm were prepared by dissolving calculated chemical in one litre of water, whereas calcium chloride ($CaCl_2$) of 25 and 50 ppm were prepared by dissolving 25 and 50 mg in small quantity of ethyl alcohol and volume was made up to one litre.

3.5.3. EXPERIMENT III: STUDIES ON THE EFFECT OF COMBINATION OF BEST TREATMENTS OF EXPERIMENT I AND EXPERIMENT II ON POSTHARVEST VASE LIFE OF GYPSOPHILA Cv. STAR WORLD UNDER AMBIENT CONDITIONS.

Crop **:** Gypsophila (*Gypsophila paniculata*)

Cv. **:** Star World

Design **:** Completely Randomized Design (CRD)

Number of treatments **:** 04

Number of Replications **:** 06

Number of flower spikes per treatment **:** 05

Evaluation period **:** Two days interval

3. 5. 3. 1. TREATMENT DETAILS

T_1: First best of Experiment I + First best of Experiment II

T_2: First best of Experiment I + Second best of Experiment II

T_3: Second best of Experiment I + First best of Experiment II

T_4: Second best of Experiment I + Second best of Experiment II

3.6. HARVESTING EXPERIMENTAL MATERIAL

Gypsophila flowers were harvested at commercial stage with 50% of overall flowers opened. Immediately after harvest, flowers were brought to the laboratory and the basal portion of the cut flower spike was cut up to 5 cm and immersed in respective treatment vase solution.

3. 6. METHOD OF TREATMENT

3. 6. 1. Holding

In all three experiments the flowers were continuously held in the vase solutions at ambient room conditions till the end of the vase life period was defined as days from time of immersion in the test solution to the loss of ornamental value, like wilting of flowers. In experiment III, the flowers were held in the best of the holding treatment solutions of experiment I and II at ambient room conditions.

3. 7. OBSERVATIONS RECORDED

3. 7. 1. Water uptake (WB) (g. flower^{-1})

The difference between consecutive measurements of container plus solution (without flower) recorded every alternate day of interval to measure the water uptake within that particular duration of period and represented as gram per flower (Venkatarayappa *et al*., 1980)

$$WB = \frac{\text{Initial weight of container Without flower spikes} - \text{Final weight of container without flower spikes}}{\text{Number of flower spikes in the bottle}}$$

3. 7. 2. Transpirational loss of water (TLW) (g. flower^{-1})

The difference between consecutive measurements of container + solution + flowers recorded once in two days of interval to measure the transpirational loss of water within that particular duration of period and represented as gram per spike (Venkatarayappa *et al*., 1980)

$$TLW = \frac{\text{Initial weight of container with spikes} - \text{Final weight of container with spikes}}{\text{Number of flower spikes in the bottle}}$$

3. 7. 3. Optical density of vase solution (ODVS) (480 nm)

It was measured by using spectrophotometer at 480 nm.

3. 7. 4. Vase life of flowers (days)

Number of days taken for withering of more than 50 per cent of the flowers was recorded and expressed in days.

3. 7. 5. Relative water content (RWC) (%)

It was estimated by Barr and weatherely (1962) and value was expressed in percentage.

Procedure

One gram weight of flowers were taken and soaked in distilled water for a period of four hrs. After soaking, the turgid weight was measured. Then the flowers were dried in hot air oven at 80^{0}C till the constant weight was noticed and it has been taken as dry weight and RWC was measured by using the following formula.

$$RWC = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{Dry Weight}} \times 100$$

3.7.6. physiological change in weight of flowers (PCW) (%)

It was calculated by using the following formula and expressed in percentage.

$$PCW = \frac{\text{Initial flower weight} - \text{Flower weight on the day of observation}}{\text{Initial flower weight}} \times 100$$

3. 6. 7. Water balance (WB) (g. flower^{-1})

Water balance in the flower tissue was calculated as the difference between water uptake and transpirational loss of water and represented as grams. (Venkatarayappa *et al*., 1980).

WB = WU – TLW

3. 7. 8. Fresh weight (g. flower^{-1})

It was measured by weighing of flower spike with the help of an electronic balance and was expressed in grams.

3. 7. 9. Dry weight (g. flower^{-1})

It was recorded by weighting of 50% wilting of flower on spike at ambient conditions and was expressed as grams.

3. 7. 10. Water uptake to water loss in ratio

It was calculated by using the following formula.

$$\text{Water uptake to water loss in ratio} = \frac{\text{Water uptake}}{\text{Water loss}}$$

3. 8. STATISTICAL ANALYSIS

All the three experiments data were subjected to statistical scrutiny by the method of analysis of variance outlined by Panse and Sukhatme (1978). Statistical significance was tested by F-value at five per cent level of probability and wherever the F-value was found significant critical difference was worked out at five per cent level of probability.

Data on vase life experiments were analyzed using analysis of variance (ANOVA) and F-test analysis. Significant difference (CD) was used for the comparison between the treatments. Based on the F-test, the non-significant (NS) values were ignored in the description of results.

Chapter IV

RESULTS AND DISCUSSION

In the present investigation studies were carried out to determine the effect of different floral preservatives on postharvest vase life of gypsophila (*Gypsophila paniculata* L.) Cv. Star World under ambient conditions with three experiments conducted during the year 2019-20.

Experiments were carried out with the spikes obtained from the Floricultural Research station, Rajendranagar, Hyderabad and holding them in solution consisting of two per cent sucrose and different biocides like 8-hydroxy quinoline sulphate (8-HQS), sodium hypochlorite (SH) and calcium hypochlorite ($Ca(OCl)_2$) as first experiment. In second experiment vase solution of two per cent sucrose and certain antioxidants like ascorbic acid (AA), potassium meta bisulphite (KMS) and calcium chloride ($CaCl_2$) were studied to determine the postharvest vase life of cut gypsophila. The effect of combination of best treatments of experiment one and two were investigated in third experiment to find out correct combination of vase solution to enhance the vase life of cut gypsophila.

The data collected during the study were statistically analyzed and the results obtained are discussed in this chapter under respective heads.

4.1. Effect of sucrose and biocides on postharvest vase life of gypsophila (*Gypsophila paniculata* L.) Cv. Star World under ambient conditions.

4.1.1. Water uptake (WU) (g. flower^{-1})

The data recorded on changes in WU during vase life period of cut gypsophila Cv. Star World treated with biocides are presented in the table 4.4.1. and depicted in fig. 4.4.1

All biocide treatments differed significantly on WU. Highest WU was recorded in T_9 treatment (sucrose @ 2 % + 8 - HQS @ 200 ppm)

Table 4.1.1. Effect of sucrose and biocides on water uptake (g flower^{-1}) of gypsophila Cv. Star World

Treatments (T)	Water uptake (g flower^{-1})					
	Days					
	1	3	5	7	9	Mean
T_1 Sucrose 2 %	16.3	15.3	13.6	11.3	10.3	13.36 ^{bc}
T_2 8HQS 100 ppm	18.6	15.6	13.3	11.6	11.3	14.08 ^{b}
T_3 8HQS 200 ppm	17.3	14.3	13	12.3	11.6	13.70 ^{bc}
T_4 SH 25 ppm	14	13.3	12.3	11.3	10.3	12.24 ^{bc}
T_5 SH 50 ppm	16	15.6	14.3	12.6	10.6	13.82 ^{bc}
T_6 $Ca(OCl)_2$ 25 ppm	14	12	11.6	10.4	10	11.60 ^{bc}
T_7 $Ca(OCl)_2$ 50 ppm	14.3	13.3	11.3	10.6	9.3	11.76 ^{bc}
T_8 Sucrose 2 % + 8HQS 100 ppm	34.6	30.3	24.6	20	18.6	25.62 ^{a}
T_9 Sucrose 2 % + 8HQS 200 ppm	36.3	30.6	25	23.6	21.6	27.42^{a}
T_{10} Sucrose 2 % + SH 25 ppm	18.3	18	16.6	14.3	13	16.04 ^{b}
T_{11} Sucrose 2 % + SH 50 ppm	23	21.6	19	18.3	16.6	19.70 ^{ab}
T_{12} Sucrose 2 % + $Ca(OCl)_2$ 25 ppm	19.3	16.3	13.6	11	10.6	14.16 ^{b}
T_{13} Sucrose 2 % + $Ca(OCl)_2$ 50 ppm	18.6	17.6	15	14.6	12.3	15.62 ^{b}
T_{14} Control (Distilled water)	13.6	11.6	10.6	9.4	9.3	10.90 ^{c}
S.Em	2.05					
CD (p = 0.05)	5.76					

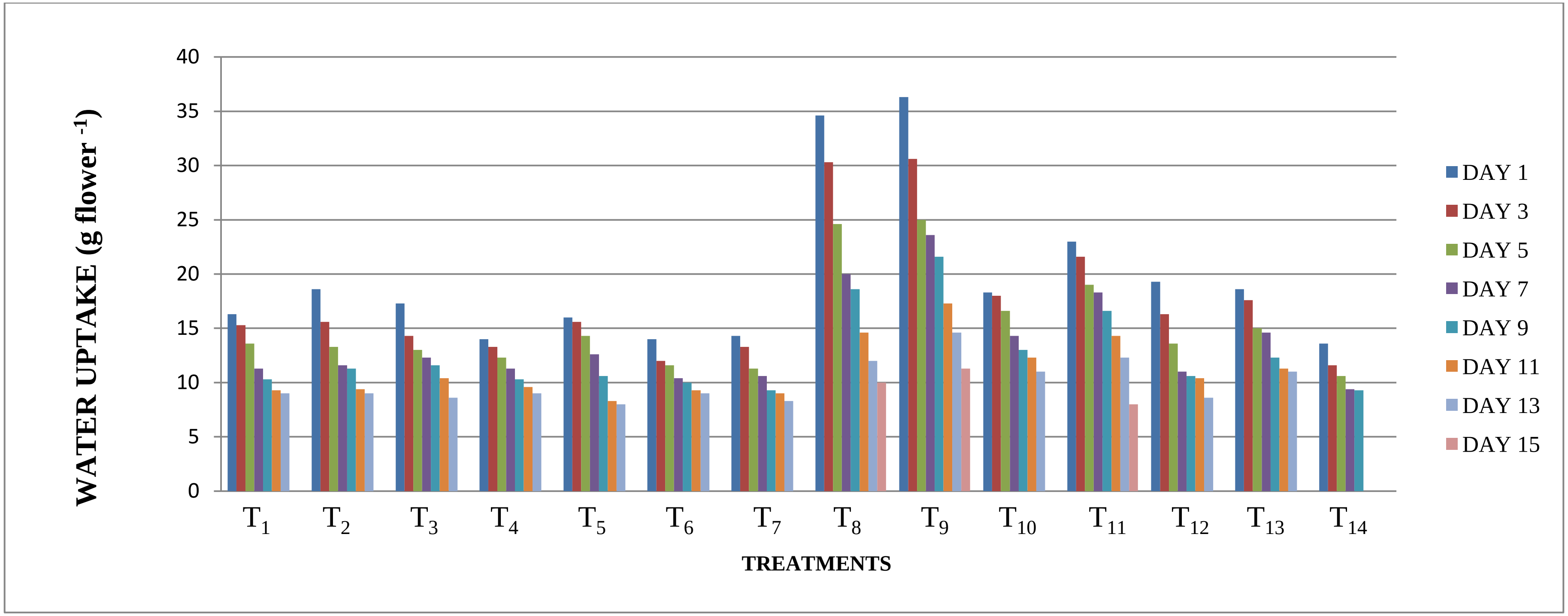

Fig.4.1.1. Effect of sucrose and biocides on water uptake (g flower $^{-1}$) of gypsophila Cv. Star World

T_1 - sucrose @ 2%, T_2 - 8HQS @ 100 ppm, T_3 - 8HQS @ 200 ppm, T_4 - $NaOCl_2$ @ 25 ppm, T_5 - $NaOCl_2$ @ 50 ppm, T_6 - $Ca(OCl)_2$ @ 25 ppm, T_7 - $Ca(OCl)_2$ @ 50 ppm, T_8 - Sucrose @ 2 % + 8HQS @ 100 ppm, T_9 -Sucrose @ 2 % + 8HQS @ 200 ppm, T_{10} - Sucrose @ 2 % + $NaOCl_2$ @ 25 ppm, T_{11}- Sucrose @ 2 % + $NaOCl_2$ @ 50 ppm, T_{12} - Sucrose @ 2 % + Ca $(OCl)_2$ @ 25 ppm, T_{13} - Sucrose @ 2 % + Ca $(OCl)_2$ @ 50 ppm and T_{14} - Control (Distilled water).

(27.42 g $flower^{-1}$), followed by T_8 (25.62 g $flower^{-1}$) and T_{11} treatments (19.70 g $flower^{-1}$) and were on par with each other, whereas lowest WU was recorded in T_{14} treatment (control) (10.90 g $flower^{-1}$) and was comparable with T_6 (11.60 g $flower^{-1}$), T_7 (11.76 g $flower^{-1}$), T_4 (12.24 g $flower^{-1}$), T_5 (13.82 g $flower^{-1}$), T_3 (13.70 g $flower^{-1}$) and T_1 treatments (13.36 g $flower^{-1}$).

The highest water uptake was recorded in T_9 (sucrose @ 2 % + 8-HQS @ 200 ppm) treatment which was due to the enhanced and continuous water uptake by this treatment might be responsible for delaying senescence. Sucrose act as respiratory substrate. Sven and Jose (2004) reported that sucrose maintained water balance and delayed turgidity loss as the flower senescence.

Hwang and Kim (1995) in gladiolus reported that four per cent of sucrose plus 8-HQS gave better results over other treatments. They also opined that 8-HQS is known for improvement of mineral salt up take through their influence on metal ions which might have resulted in maximum solution up take. Pruthi *et al.* (2001) also found that in gladiolus enhancement of solution uptake has taken place at higher concentrations of biocides.

4.1.2. Transpirational loss of water (TLW) (g. $flower^{-1}$)

The data pertaining to changes in TLW during vase life period of cut gypsophila Cv. Star World treated with biocides are presented in the table 4.4.2.

All biocide treatments were differed significantly with respect to TLW. The highest TLW was recorded in T_9 treatment (sucrose @ 2 % + 8 - HQS @ 200 ppm) (22.22 g $flower^{-1}$), followed by T_8 (sucrose @ 2 % + 8 - HQS @ 100 ppm) (20.24 g $flower^{-1}$), T_{11} (sucrose @ 2 % + SH @ 50 ppm) (19.06 g $flower^{-1}$), T_{10} (sucrose @ 2 % + SH @ 25 ppm) (18.08 g $flower^{-1}$), T_{13} (sucrose @ 2 % + $Ca(OCl)_2$ @ 50 ppm) (17.76 g $flower^{-1}$, T_{12} (sucrose @ 2 % + $Ca(OCl)_2$ @ 25 ppm) (16.22 g $flower^{-1}$) and T_2 treatments (8HQS @ 100 ppm) (15.50 g $flower^{-1}$) and were non significant

Table 4.1.2. Effect of sucrose and biocides on transpirational loss of water (g flower^{-1}) of gypsophila Cv. Star World

Treatments (T)	Transpirational loss of water (g flower^{-1})					
	Days					
	1	3	5	7	9	Mean
T_1 Sucrose 2 %	14	13.6	12.6	12.3	11	12.70 ^{c}
T_2 8HQS 100 ppm	18.3	16.6	15.3	14	13.3	15.50 ^{ab}
T_3 8HQS 200 ppm	14.6	14	13.6	12.3	11.3	13.16 ^{bc}
T_4 SH 25 ppm	15	14.4	12.6	11.3	10	12.66 ^{c}
T_5 SH 50 ppm	16.6	15.6	15.3	13.4	11.7	14.52 ^{b}
T_6 $Ca(OCl)_2$ 25 ppm	13.3	12.3	11	10.2	9.3	11.22 ^{d}
T_7 $Ca(OCl)_2$ 50 ppm	14.7	13.4	11.6	10.3	10	12.00 ^{cd}
T_8 Sucrose 2 % + 8HQS 100 ppm	24	22.6	20.3	18	16.3	20.24 ^{a}
T_9 Sucrose 2 % + 8HQS 200 ppm	27	25.4	22	19.4	17.3	22.22 ^{a}
T_{10} Sucrose 2 % + SH 25 ppm	24	19.4	17	16.3	13.7	18.08 ^{a}
T_{11} Sucrose 2 % + SH 50 ppm	25	21.4	18	16.3	14.6	19.06 ^{a}
T_{12} Sucrose 2 % + $Ca(OCl)_2$ 25 ppm	19.6	17.6	15.3	14.6	14	16.22 ^{ab}
T_{13} Sucrose 2 % + $Ca(OCl)_2$ 50 ppm	24.6	20	17.6	14.3	12.3	17.76 ^{a}
T_{14} Control (Distilled water)	12.6	11.3	10.4	9.3	9	10.52 ^{d}
S.Em	2.02					
CD (p = 0.05)	5.67					

with each other, while it was lowest in T_{14} treatment (control) (10.52 g flower^{-1}) and was comparable with T_6 ($Ca(OCl)_2$ @ 25 ppm) (11.22 g flower^{-1}) and T_7 treatments ($Ca(OCl)_2$ @ 50 ppm) (12.00 g flower^{-1}).

The highest TLW in T_9 treatment (sucrose @ 2 % + 8 - HQS @ 200 ppm) was due to adequate and controlled transpirational loss of water in response of enhanced water up take. Sucrose and 8-HQS reduces the blockage in stem tissue which improves the water balance and osmotic potential by maintaining the turgidity. (Bravdo *et al*., 1974)

4.1.3. Optical density of vase solution (ODVS) (nm)

The data enunciated on changes in optical density of vase solution during vase life period of cut gypsophila Cv. Star World treated with biocide solutions are presented in the table 4.1.3.

The mean of ODVS was found significantly differed among the biocide treatments. Lowest value was recorded in T_9 treatment (sucrose @ 2 % + 8-HQS @ 200 ppm) (0.045 nm) and was statistically non significant with most of the treatments *viz*., T_8 (sucrose @ 2 % + 8 - HQS @ 100 ppm) (0.056 nm), T_{11} (sucrose @ 2 % + SH @ 50 ppm) (0.064 nm), T_{10} (sucrose @ 2 % + SH @ 25 ppm) (0.070 nm), T_{13} (sucrose @ 2 % + $Ca(OCl)_2$ @ 50 ppm) (0.072 nm), T_{12} (sucrose @ 2 % + $Ca(OCl)_2$ @ 25 ppm) (0.075 nm), T_2 (8HQS @ 100 ppm) (0.078 nm), T_5 (SH @ 50 ppm) (0.081 nm), T_3 (8HQS @ 200 ppm) (0.084 nm) and T_1 treatments (sucrose @ 2 %) (0.094 nm), while it was highest in T_{14} treatment (control) (0.173 nm) followed by T_6 ($Ca(OCl)_2$ @ 25 ppm) (0.164 nm) and were on par with each other.

The lowest ODVS in T_9 treatment (sucrose @ 2 % + 8 - HQS @ 200 ppm) might be due to low bacterial count as this treatment registered maximum water up take and transpirational loss of water than other treatments.

Table 4.1.3. Effect of sucrose and biocides on optical density of vase solution (480nm) of gypsophila Cv. Star World

Treatments (T)	**Optical density of vase solution (480nm)**					
	Days					
	1	**3**	**5**	**7**	**9**	**Mean**
T_1 Sucrose 2 %	0.051	0.072	0.091	0.112	0.142	0.094 [a]
T_2 8HQS 100 ppm	0.049	0.061	0.083	0.095	0.103	0.078 [a]
T_3 8HQS 200 ppm	0.039	0.048	0.096	0.112	0.124	0.084 [a]
T_4 SH 25 ppm	0.074	0.113	0.128	0.151	0.164	0.126 [b]
T_5 SH 50 ppm	0.059	0.068	0.074	0.099	0.107	0.081 [a]
T_6 $Ca(OCl)_2$ 25 ppm	0.087	0.108	0.119	0.231	0.274	0.164 [cd]
T_7 $Ca(OCl)_2$ 50 ppm	0.073	0.128	0.136	0.172	0.204	0.143 [c]
T_8 Sucrose 2 % + 8HQS 100 ppm	0.039	0.044	0.057	0.062	0.079	0.056 [a]
T_9 Sucrose 2 % + 8HQS 200 ppm	0.038	0.043	0.045	0.047	0.05	0.045 [a]
T_{10} Sucrose 2 % + SH 25 ppm	0.055	0.063	0.064	0.072	0.087	0.070 [a]
T_{11} Sucrose 2 % + SH 50 ppm	0.042	0.054	0.067	0.075	0.081	0.064 [a]
T_{12} Sucrose 2 % + $Ca(OCl)_2$ 25 ppm	0.045	0.054	0.061	0.075	0.087	0.075 [a]
T_{13} Sucrose 2 % + $Ca(OCl)_2$ 50 ppm	0.049	0.058	0.074	0.089	0.097	0.072 [a]
T_{14} Control (Distilled water)	0.096	0.138	0.171	0.205	0.256	0.173 [d]
S.Em	0.021					
CD (p = 0.05)	0.059					

4.1.4. Vase life (days)

Data recorded on vase life of cut gypsophila Cv. Star World held in different biocide solutions are presented in table 4.1.4. and depicted in fig. 4.1.2.

All biocide treatments differed significantly on this parameter. The highest vase life (15.5 days) was recorded in T_9 treatment (sucrose @ 2 % + 8 - HQS @ 200 ppm) (Plate 2), followed by T_8 (sucrose @ 2 % + 8 - HQS @ 100 ppm) (14 days) (Plate 3) and T_{11} treatments (sucrose @ 2 % + SH @ 50 ppm) (13.5 days) and were comparable with each other, whereas significantly lowest vase life (8.8 days) was registered with T_{14} treatment (control).

Observations from table 4.1.4. confirm that T_9 treatment was most effective in enhancing the vase life might be due to the same treatment registered the higher WU, TLW and lowest ODVS than other treatments, resulted in longer vase life. Similar results were also reported by Laksminarayana and Prashath (2020a) in gladiolus.

4.1.5. Relative water content (RWC) (%)

The results related to relative water content during vase life period of cut gypsophila Cv. Star World with biocide solutions are presented in the table 4.1.5.

All treatments showed non significant with respect to relative water content. Highest relative water content (96.38 %) was recorded in T_9 treatment (sucrose @ 2 % + 8 - HQS @ 200 ppm), followed by T_8 treatment (sucrose @ 2 % + 8 - HQS @ 100 ppm) (90.94 %) and were comparable with each other, whereas it was significantly lowest in T_{14} treatment (control) (72.76 %).

The higher relative water content in T_9 treatment (sucrose @ 2 % + 8-HQS @ 200 ppm) which was due to maximum water uptake and transpirational loss of water of this treatment as compared to other treatments. Hassan and Ali (2014) found that 8-HQS enhanced the relative

Table 4.1.4. Effect of sucrose and biocides on vase life (days) of gypsophila Cv. Star World

Treatments (T)	**Vase life (days)**
T_1 Sucrose 2 %	11.2^{cd}
T_2 8HQS 100 ppm	12^{bc}
T_3 8HQS 200 ppm	11.7^{c}
T_4 SH 25 ppm	11^{d}
T_5 SH 50 ppm	11.8^{c}
T_6 $Ca(OCl)_2$ 25 ppm	10.7^{ef}
T_7 $Ca(OCl)_2$ 50 ppm	10.8^{e}
T_8 Sucrose 2 % + 8HQS 100 ppm	14^{ab}
T_9 Sucrose 2 % + 8HQS 200 ppm	15.5^{a}
T_{10} Sucrose 2 % + SH 25 ppm	12.8^{b}
T_{11} Sucrose 2 % + SH 50 ppm	13.5^{ab}
T_{12} Sucrose 2 % + $Ca(OCl)_2$ 25 ppm	12.2^{bc}
T_{13} Sucrose 2 % + $Ca(OCl)_2$ 50 ppm	12.5^{bc}
T_{14} Control (Distilled water)	8.8^{f}
S.Em	0.41
CD (p = 0.05)	1.20

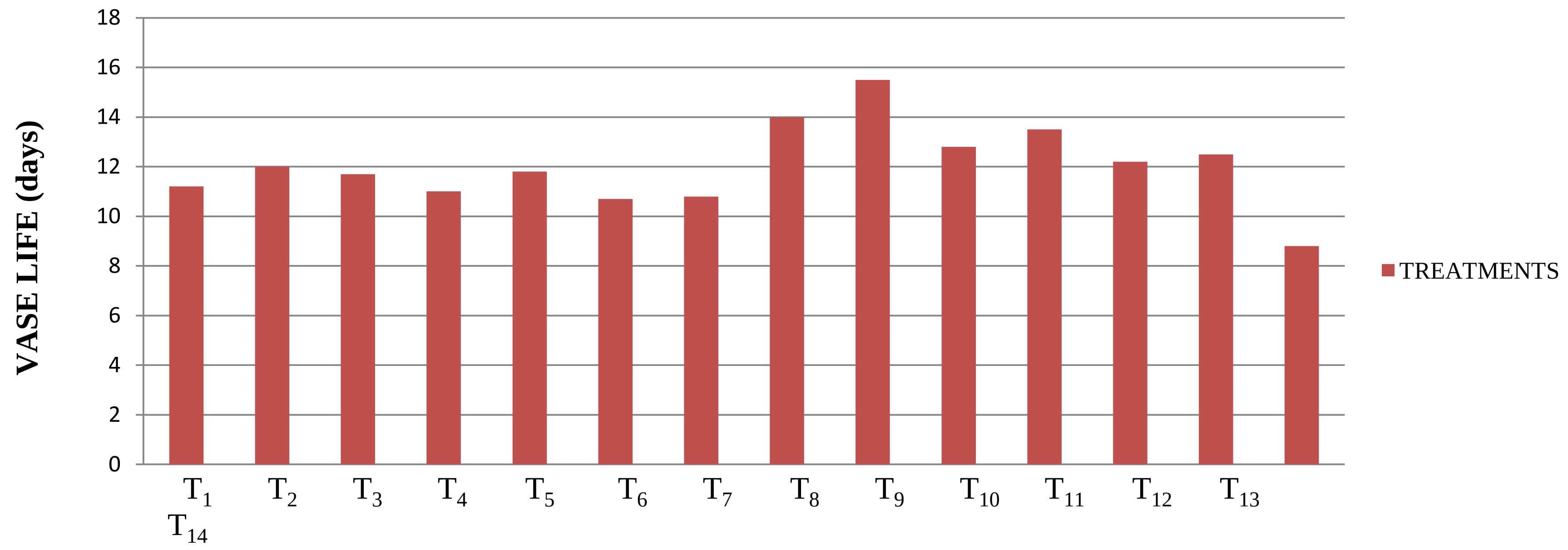

Fig. 4.1.2. Effect of sucrose and biocides on vase life (days) of gypsophila Cv. Star World

T_1 - sucrose @ 2%, T_2 - 8HQS @ 100 ppm, T_3 - 8HQS @ 200 ppm, T_4 - $NaOCl_2$ @ 25 ppm, T_5 - $NaOCl_2$ @ 50 ppm, T_6 - $Ca(OCl)_2$ @ 25 ppm, T_7 - $Ca(OCl)_2$ @ 50 ppm, T_8 - Sucrose @ 2 % + 8HQS @ 100 ppm, T_9 -Sucrose @ 2 % + 8HQS @ 200 ppm, T_{10} - Sucrose @ 2 % + $NaOCl_2$ @ 25 ppm, T_{11}- Sucrose @ 2 % + $NaOCl_2$ @ 50 ppm, T_{12} - Sucrose @ 2 % + Ca $(OCl)_2$ @ 25 ppm, T_{13} - Sucrose @ 2 % + Ca $(OCl)_2$ @ 50 ppm and T_{14} - Control (Distilled water).

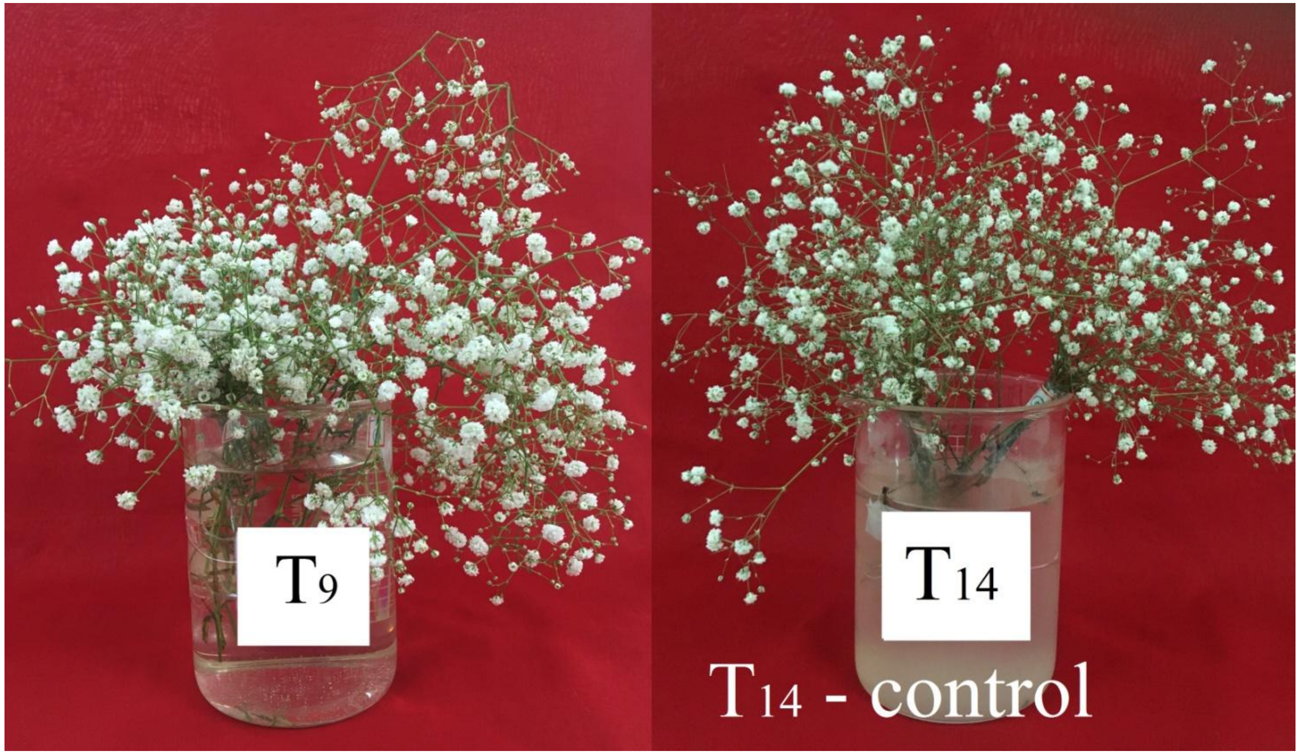

Plate. 2 Comparison of flower quality on 9th day of vase life of T_9 with control in experiment I

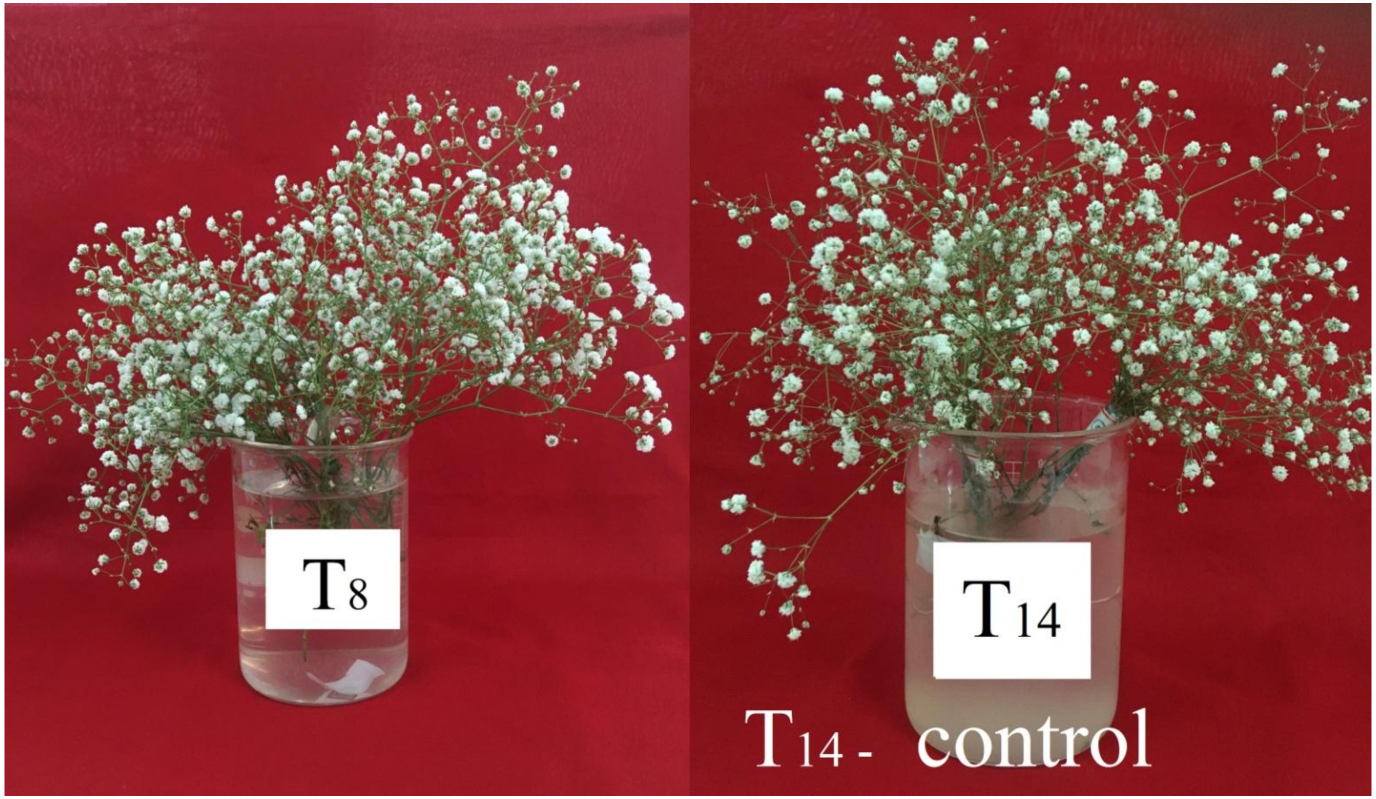

Plate. 3 Comparison of flower quality on 9th day of vase life of T_8 with control in experiment I

Table 4.1.5. Effect of sucrose and biocides on relative water content (%) of gypsophila Cv. Star World

Treatments (T)	**Relative water content (%)**					
	Days					
	1	**3**	**5**	**7**	**9**	**Mean**
$\mathbf{T_1}$ Sucrose 2 %	75.8	79.6	80.4	83.2	85.7	79.80
$\mathbf{T_2}$ 8HQS 100 ppm	80	81.4	83.3	85.9	87.8	83.68
$\mathbf{T_3}$ 8HQS 200 ppm	71.2	76.7	82.2	85.6	87.3	80.60
$\mathbf{T_4}$ SH 25 ppm	74.7	77.6	80.4	83.2	80.01	79.20
$\mathbf{T_5}$ SH 50 ppm	78.6	80.4	83.4	85.6	82.9	82.18
$\mathbf{T_6}$ $Ca(OCl)_2$ 25 ppm	70.9	75.4	79.6	82.6	81.7	78.04
$\mathbf{T_7}$ $Ca(OCl)_2$ 50 ppm	72.6	75.8	81.2	83.7	80.4	78.74
$\mathbf{T_8}$ Sucrose 2 % + 8HQS 100 ppm	84.7	89.7	94.6	98.5	87.2	90.94
$\mathbf{T_9}$ Sucrose 2 % + 8HQS 200 ppm	90.6	95.2	98.1	101.3	96.7	96.38
$\mathbf{T_{10}}$ Sucrose 2 % + SH 25 ppm	82.6	84.1	86.9	89.8	85.3	85.74
$\mathbf{T_{11}}$ Sucrose 2 % + SH 50 ppm	83.5	85.3	88.6	90.7	87.1	87.04
$\mathbf{T_{12}}$ Sucrose 2 % + $Ca(OCl)_2$ 25 ppm	81.3	83.6	84.7	87.1	85.7	84.50
$\mathbf{T_{13}}$ Sucrose 2 % + $Ca(OCl)_2$ 50 ppm	80.6	82.4	84.1	87.3	89.7	84.80
$\mathbf{T_{14}}$ Control (Distilled water)	70.2	73.6	80.4	71.3	68.3	72.76
S.Em	9.37					
CD (p = 0.05)	N.S.					

water content (RWC) of leaves and maintained chlorophyll and carbohydrate content, minimized ethylene production and retained membrane stability in gladiolus.

4.1.6. Physiological change in weight (PCW) (%)

The data recorded on changes in physiological change in weight during vase life period of cut gypsophila Cv. Star World treated with biocides are presented in the table 4.1.6.and depicted in fig. 4.1.3.

All biocide treatments were differed significantly on physiological change in weight. The lowest value was recorded in T_9 treatment (sucrose @ 2 % + 8 - HQS @ 200 ppm) (0.82 %) and it was on par with T_8 (sucrose @ 2 % + 8 - HQS @ 100 ppm) (1.084 %) and T_{11} treatments (sucrose @ 2 % + SH @ 50 ppm) (1.158 %), while highest in T_{14} treatment (control) (4.636 %) and was comparable with T_6 **(**$Ca(OCl)_2$ @ 25 ppm) (3.562 %), T_7 **(**$Ca(OCl)_2$ @ 50 ppm) (3.368 %), T_4 (SH @ 25 ppm) (2.774 %), T_1 (sucrose @ 2 %) (1.852 %) and T_3 treatments (8HQS @ 200 ppm) (1.766 %).

The lowest PCW was reported in T_9 treatment which might be due to the same reason studied for the vase life parameter. The present findings are in line with the reports of Joshi, 2012 in gerbera.

4.1.7. Water balance (WB) (g. flower^{-1})

The results related to changes in water balance during vase life period of cut gypsophila Cv. Star World treated with biocides are presented in the table 4.1.7.

All biocide treatments differed significantly on water balance. It was observed that, most of the treatments showed negative water balance except four treatments *viz*., T_8, T_9, T_1 and T_{14}. The highest water balance was recorded in T_8 treatment (sucrose @ 2 % + 8 - HQS @ 100 ppm) (5.24 g flower^{-1}), followed by T_9 treatment (sucrose @ 2 % + 8 - HQS @ 200 ppm) (5.2 g flower^{-1}) and were statistically on par with each other,

Table 4.1.6. Effect of sucrose and biocides on physiological change in weight (%) of gypsophila Cv. Star World

Treatments (T)	Physiological change in weight (%)					
	Days					
	1	3	5	7	9	Mean
T_1 Sucrose 2 %	0.37	0.92	1.74	2.81	3.42	1.852 [b]
T_2 8HQS 100 ppm	0.32	0.63	1.16	2.72	3.07	1.58 [b]
T_3 8HQS 200 ppm	0.18	0.75	1.96	2.73	3.21	1.766 [b]
T_4 SH 25 ppm	0.25	1.26	3.06	4.2	5.1	2.774 [b]
T_5 SH 50 ppm	0.37	0.86	1.29	2.06	2.92	1.5 [b]
T_6 $Ca(OCl)_2$ 25 ppm	0.55	2.8	3.74	4.9	5.82	3.562 [c]
T_7 $Ca(OCl)_2$ 50 ppm	0.45	2.51	3.63	4.79	5.46	3.368 [c]
T_8 Sucrose 2 % + 8HQS 100 ppm	0.27	0.49	0.98	1.56	2.12	1.084 [ab]
T_9 Sucrose 2 % + 8HQS 200 ppm	0.1	0.43	0.74	1.8	1.03	0.82 [a]
T_{10} Sucrose 2 % + SH 25 ppm	0.31	0.56	1.03	1.74	2.4	1.208 [ab]
T_{11} Sucrose 2 % + SH 50 ppm	0.22	0.37	0.93	2.74	1.53	1.158 [ab]
T_{12} Sucrose 2 % + $Ca(OCl)_2$ 25 ppm	0.32	0.72	1.26	1.85	3.06	1.442 [ab]
T_{13} Sucrose 2 % + $Ca(OCl)_2$ 50 ppm	0.26	0.45	1.02	3.62	1.36	1.342 [ab]
T_{14} Control (Distilled water)	1.24	3.7	4.5	6.72	7.02	4.636 [c]
S.Em	0.463					
CD (p = 0.05)	1.295					

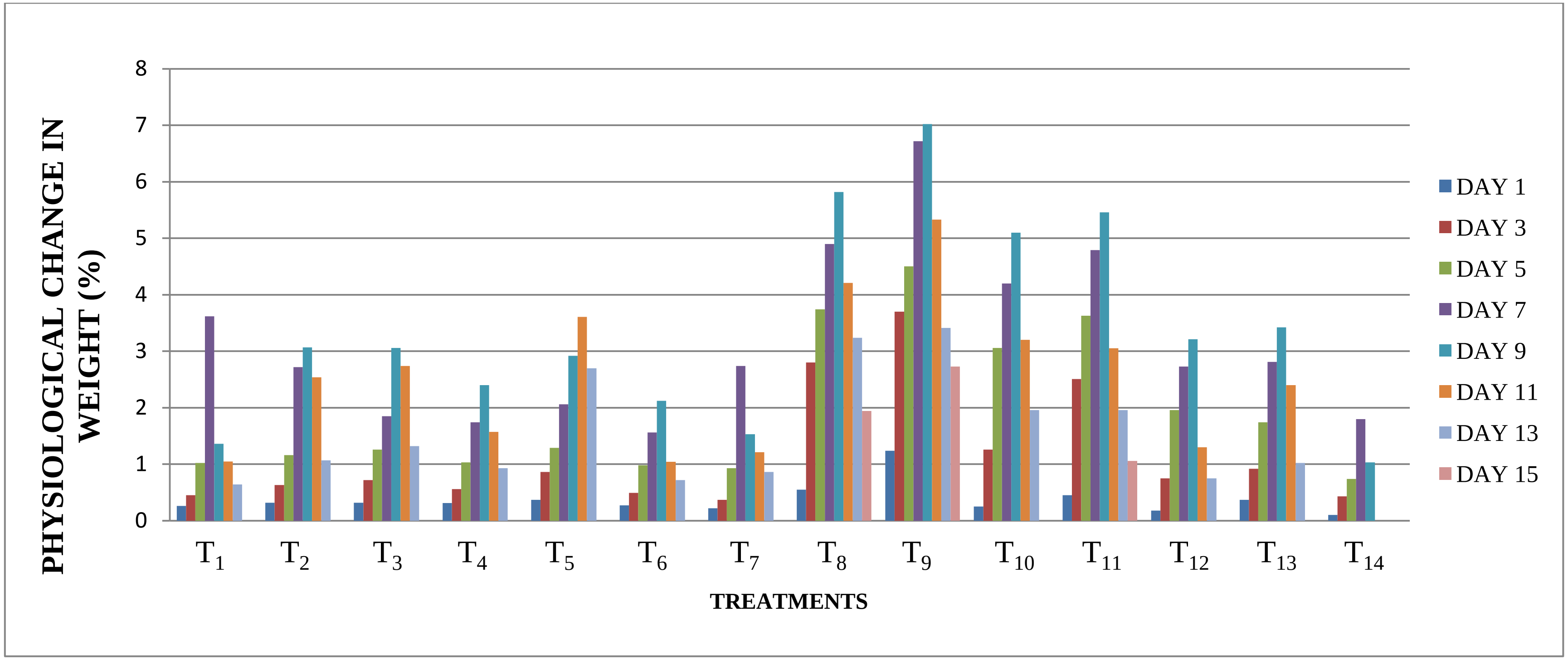

Fig.4.1.3. Effect of sucrose and biocides on physiological change in weight (%) of gypsophila Cv. Star World

T_1 - sucrose @ 2%, T_2 - 8HQS @ 100 ppm, T_3 - 8HQS @ 200 ppm, T_4 - $NaOCl_2$ @ 25 ppm, T_5 - $NaOCl_2$ @ 50 ppm, T_6 - $Ca(OCl)_2$ @ 25 ppm, T_7 - $Ca(OCl)_2$ @ 50 ppm, T_8 - Sucrose @ 2 % + 8HQS @ 100 ppm, T_9 -Sucrose @ 2 % + 8HQS @ 200 ppm, T_{10} - Sucrose @ 2 % + $NaOCl_2$ @ 25 ppm, T_{11}- Sucrose @ 2 % + $NaOCl_2$ @ 50 ppm, T_{12} - Sucrose @ 2 % + Ca $(OCl)_2$ @ 25 ppm, T_{13} - Sucrose @ 2 % + Ca $(OCl)_2$ @ 50 ppm and T_{14} - Control (Distilled water).

Table 4.1.7. Effect of sucrose and biocides on water balance (g flower^{-1}) of gypsophila Cv. Star World

Treatments (T)	Water balance (g flower^{-1})					
	Days					
	1	3	5	7	9	Mean
T_1 Sucrose 2 %	2.3	1.7	1	-1	-0.7	0.66 ^{b}
T_2 8HQS 100 ppm	0.3	-1	-2	-2.4	-2	-1.42 ^{cd}
T_3 8HQS 200 ppm	1.4	1.6	0.7	0.3	-0.7	0.66 ^{b}
T_4 SH 25 ppm	-1	-1.1	-0.6	0	0.3	-0.48 ^{bc}
T_5 SH 50 ppm	0.7	-1.3	-2.3	-1.1	-0.1	-0.82 ^{c}
T_6 $Ca(OCl)_2$ 25 ppm	0.7	-0.3	0.6	0.8	1	-0.82 ^{c}
T_7 $Ca(OCl)_2$ 50 ppm	-0.4	-0.1	-0.3	0.3	-0.7	-0.24 ^{bc}
T_8 Sucrose 2 % + 8HQS 100 ppm	10.6	7.7	4.3	2	2.3	5.24 ^{a}
T_9 Sucrose 2 % + 8HQS 200 ppm	9.3	5.2	3	4.2	4.3	5.2 ^{a}
T_{10} Sucrose 2 % + SH 25 ppm	-5.7	-1.4	-0.4	-2	-0.7	-2.04 ^{d}
T_{11} Sucrose 2 % + SH 50 ppm	-2	0.2	1	2	2	0.64 ^{b}
T_{12} Sucrose 2 % + $Ca(OCl)_2$ 25 ppm	-0.3	-1.3	-1.7	-3.6	-3.4	2.06 ^{b}
T_{13} Sucrose 2 % + $Ca(OCl)_2$ 50 ppm	-6	-2.4	-2.6	0.3	0	-2.14 ^{e}
T_{14} Control (Distilled water)	1	0.3	0.2	0.1	0.3	0.38 ^{bc}
S.Em	0.59					
CD (p = 0.05)	1.64					

while significantly lowest was noticed in T_{13} treatment (sucrose @ 2 % + $Ca(OCl)_2$ @ 50 ppm) (-2.14 g flower^{-1}).

It is evident from table that the maximum water balance was recorded in T_8 treatment and it was comparable with T_9 treatment which was due to the same treatments registered highest water uptake and transpirational loss of water than other treatments.

4.1.8 Fresh weight (g. flower^{-1})

Fresh weight of flower as influenced by the biocide treatments are presented in the table 4.1.8. and depicted in fig. 4.1.4.

There was significant difference observed on fresh weight due to biocides treatments. Among the treatments, T_9 treatment (sucrose @ 2 % + 8 - HQS @ 200 ppm) recorded the highest fresh weight (15.9 g flower^{-1}) and was statistically non significant with T_8 (15.8 g flower^{-1}), T_{11} (15.6 g flower^{-1}), T_{10} (15.27 g flower^{-1}), T_{13} (15 g flower^{-1}), T_{12} (14.8 g flower^{-1}), T_2 (14.6 g flower^{-1}), T_5 (14.53 g flower^{-1}), T_3 (14.37 g flower^{-1}), T_1 (14.2 g flower^{-1}), T_4 (14 g flower^{-1}), T_7 (13.8 g flower^{-1}) and T_6 treatments (13.47 g flower^{-1}), while lowest was noticed in T_{14} treatment (control) (11.07 g flower^{-1}).

The highest fresh weight in T_9 treatment was due to the same treatment recorded maximum water uptake, transpirational loss of water and vase life over other treatments. The positive effect of 8-HQS on retaining the fresh weight could be attributed to more water up take (Uthaichay *et al*., 2007). Similar results were also reported by Martha *et al.* (2011) in rose. These results are in line with the findings of Kwon and Kim, 2000 in freesia.

4.1.9. Dry weight (g. flower^{-1})

The data pertaining to dry weight of flower affected by the treatments of biocide are presented in the table 4.1.9.

Significant difference was observed among the biocide treatments on this parameter. Maximum value was recorded in T_9

Table 4.1.8. Effect of sucrose and biocides on fresh weight (g $flower^{-1}$) of gypsophila Cv. Star World

Treatments (T)	**Fresh weight (g)**
T_1 Sucrose 2 %	14.2 [a]
T_2 8HQS 100 ppm	14.6 [a]
T_3 8HQS 200 ppm	14.37 [a]
T_4 SH 25 ppm	14 [a]
T_5 SH 50 ppm	14.53 [a]
T_6 $Ca(OCl)_2$ 25 ppm	13.47 [ab]
T_7 $Ca(OCl)_2$ 50 ppm	13.8 [a]
T_8 Sucrose 2 % + 8HQS 100 ppm	15.8 [a]
T_9 Sucrose 2 % + 8HQS 200 ppm	15.9 [a]
T_{10} Sucrose 2 % + SH 25 ppm	15.27 [a]
T_{11} Sucrose 2 % + SH 50 ppm	15.6 [a]
T_{12} Sucrose 2 % + $Ca(OCl)_2$ 25 ppm	14.8 [a]
T_{13} Sucrose 2 % + $Ca(OCl)_2$ 50 ppm	15 [a]
T_{14} Control (Distilled water)	11.07 [b]
S.Em	0.85
CD (p = 0.05)	2.47

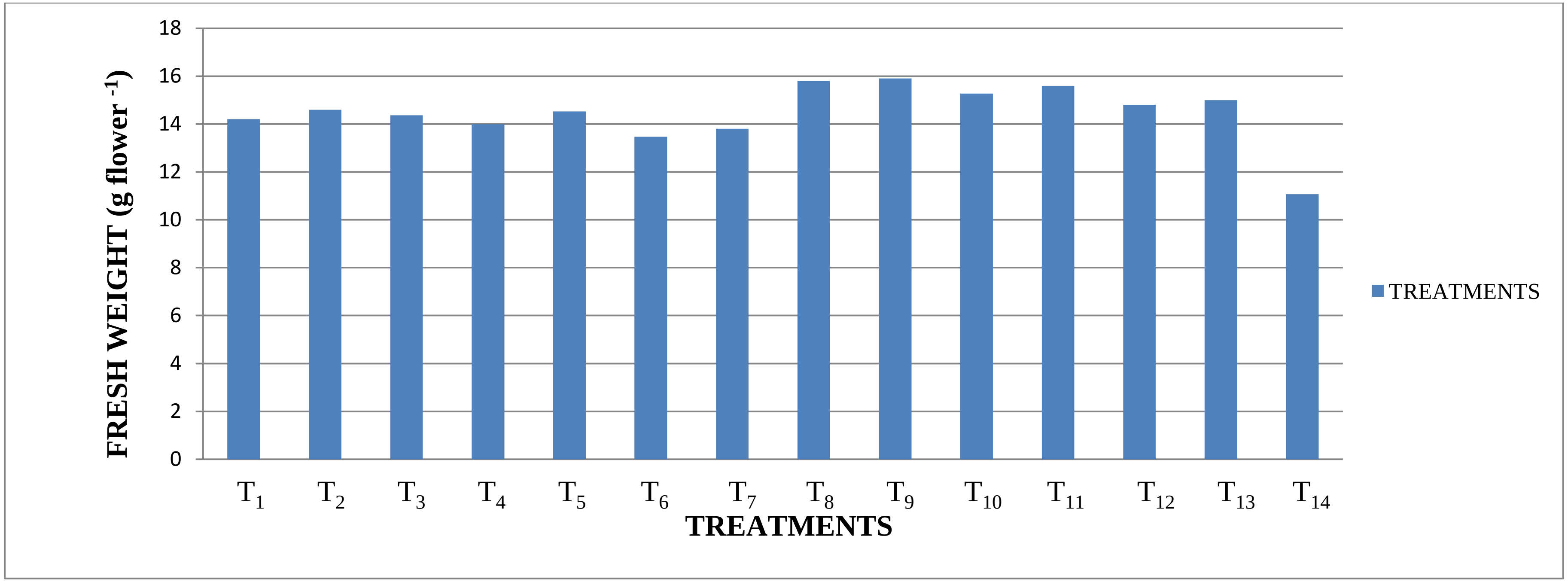

Fig.4.1.4. Effect of sucrose and biocides on fresh weight (g flower $^{-1}$) of gypsophila Cv. Star World

T_1 - sucrose @ 2%, T_2 - 8HQS @ 100 ppm, T_3 - 8HQS @ 200 ppm, T_4 - $NaOCl_2$ @ 25 ppm, T_5 - $NaOCl_2$ @ 50 ppm, T_6 - $Ca(OCl)_2$ @ 25 ppm, T_7 - $Ca(OCl)_2$ @ 50 ppm, T_8 - Sucrose @ 2 % + 8HQS @ 100 ppm, T_9 -Sucrose @ 2 % + 8HQS @ 200 ppm, T_{10} - Sucrose @ 2 % + $NaOCl_2$ @ 25 ppm, T_{11}- Sucrose @ 2 % + $NaOCl_2$ @ 50 ppm, T_{12} - Sucrose @ 2 % + Ca $(OCl)_2$ @ 25 ppm, T_{13} - Sucrose @ 2 % + Ca $(OCl)_2$ @ 50 ppm and T_{14} - Control (Distilled water).

Table 4.1.9. Effect of sucrose and biocides on dry weight (g flower^{-1}) of gypsophila Cv. Star World

Treatments (T)	**Dry weight (g)**
T_1 Sucrose 2 %	7.8 ^{b}
T_2 8HQS 100 ppm	8.06 ^{ab}
T_3 8HQS 200 ppm	7.93 ^{ab}
T_4 SH 25 ppm	7.7 ^{b}
T_5 SH 50 ppm	8 ^{ab}
T_6 $Ca(OCl)_2$ 25 ppm	7.2 ^{c}
T_7 $Ca(OCl)_2$ 50 ppm	7.6 ^{b}
T_8 Sucrose 2 % + 8HQS 100 ppm	8.8 ^{a}
T_9 Sucrose 2 % + 8HQS 200 ppm	9.4 ^{a}
T_{10} Sucrose 2 % + SH 25 ppm	8.53 ^{a}
T_{11} Sucrose 2 % + SH 50 ppm	8.6 ^{a}
T_{12} Sucrose 2 % + $Ca(OCl)_2$ 25 ppm	8.13 ^{ab}
T_{13} Sucrose 2 % + $Ca(OCl)_2$ 50 ppm	8.3 ^{a}
T_{14} Control (Distilled water)	6.3 ^{d}
S.Em	0.45
CD (p = 0.05)	1.31

treatment (sucrose @ 2 % + 8 - HQS @ 200 ppm) (9.4 g flower^{-1}) and was on par with T_8 (8.8 g flower^{-1}), T_{11} (8.6 g flower^{-1}), T_{10} (8.53 g flower^{-1}), T_{13} (8.3 g flower^{-1}), T_{12} (8.13 g flower^{-1}), T_2 (8.06 g flower^{-1}), T_5 (8 g flower^{-1}) and T_3 treatments (7.93 g flower^{-1}), whereas it was minimum in T_{14} control (6.3 g flower^{-1}).

The highest dry weight was recorded in T_9 treatment which was due to maximum fresh weight of this treatment over other treatments. Samaneh *et al*. (2013) in gerbera reported that highest dry weight was recorded in the treatment of sucrose @ 30 g l^{-1} plus 8-HQS @ 200 mg l^{-1}.

4.1.10 Water uptake to water loss ratio

Table 4.1.10. and fig. 4.1.5 represents that maximum water uptake to water loss ratio was recorded in T_9 treatment (sucrose @ 2 % + 8 - HQS @ 200 ppm) (1.276), followed by T_8 (1.249), T_6 (1.054), T_{11} (1.049), T_3 (1.045), T_1 (1.045), T_{12} (1.034), T_7 (0.979), T_4 (0.968), T_5 (0.939), T_{13} (0.902), T_{10} (0.899) and T_2 treatments (0.892) and were comparable with each other, while minimum value was recorded in T_{14} treatment (control) (0.862).

It is evident from table that higher water uptake to water loss ratio was recorded in T_9 treatment which might be due to the same treatment registered higher water uptake and transpirational loss of water than other treatments.

4.2 Effect of sucrose and antioxidants on postharvest vase life of gypsophila Cv. Star World under ambient conditions.

4.2.1 Water uptake (WU) (g. flower^{-1})

The results related to changes in WU during vase life period of cut gypsophila Cv. Star World treated with antioxidant solutions are presented in the table 4.5.1.and depicted in the fig. 4.5.1

All antioxidant treatments were differed significantly with respect to WU. Among the treatments, T_{11} treatment (sucrose @ 2 % + KMS @ 200 ppm) recorded the maximum WU (31.42 g flower^{-1}),

Table 4.1.10. Effect of sucrose and biocides on water uptake to water loss ratio of gypsophila Cv. Star World

Treatments (T)	water uptake to water loss ratio					
	Days					
	1	3	5	7	9	Mean
T_1 Sucrose 2 %	1.164	1.125	1.079	0.919	0.936	1.045 [a]
T_2 8HQS 100 ppm	1.016	0.939	0.869	0.786	0.849	0.892 [ab]
T_3 8HQS 200 ppm	1.096	1.114	1.051	1.024	0.938	1.045 [a]
T_4 SH 25 ppm	0.933	0.924	0.952	1	1.03	0.968 [a]
T_5 SH 50 ppm	1.024	0.917	0.849	0.918	0.991	0.939 [ab]
T_6 $Ca(OCl)_2$ 25 ppm	1.053	0.976	1.055	1.078	1.108	1.054 [a]
T_7 $Ca(OCl)_2$ 50 ppm	0.973	0.993	0.974	1.029	0.93	0.979 [a]
T_8 Sucrose 2 % + 8HQS 100 ppm	1.442	1.341	1.212	1.111	1.141	1.249 [a]
T_9 Sucrose 2 % + 8HQS 200 ppm	1.344	1.205	1.364	1.216	1.249	1.276 [a]
T_{10} Sucrose 2 % + SH 25 ppm	0.763	0.928	0.976	0.877	0.949	0.899 [ab]
T_{11} Sucrose 2 % + SH 50 ppm	0.92	1.009	1.056	1.123	1.137	1.049 [a]
T_{12} Sucrose 2 % + $Ca(OCl)_2$ 25 ppm	1.079	1.027	1.019	1.011	1.033	1.034 [a]
T_{13} Sucrose 2 % + $Ca(OCl)_2$ 50 ppm	0.756	0.88	0.852	1.021	1	0.902 [ab]
T_{14} Control (Distilled water)	0.985	0.926	0.889	0.753	0.757	0.862 [b]
S.Em	0.119					
CD (p = 0.05)	0.335					

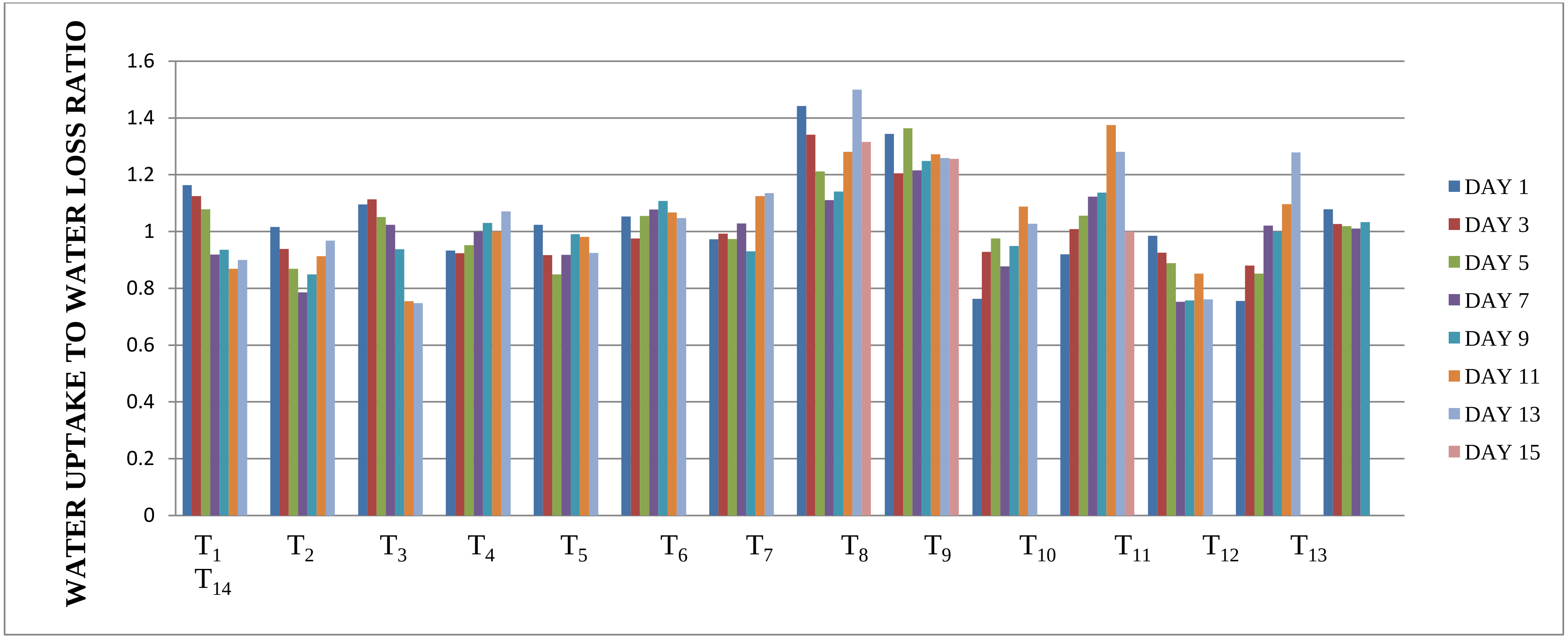

Fig. 4.1.5. Effect of sucrose and biocides on water uptake to water loss ratio of gypsophila cv. Star World

T_1 - sucrose @ 2%, T_2 - 8HQS @ 100 ppm, T_3 - 8HQS @ 200 ppm, T_4 - $NaOCl_2$ @ 25 ppm, T_5 - $NaOCl_2$ @ 50 ppm, T_6 - $Ca(OCl)_2$ @ 25 ppm, T_7 - $Ca(OCl)_2$ @ 50 ppm, T_8 - Sucrose @ 2 % + 8HQS @ 100 ppm, T_9 -Sucrose @ 2 % + 8HQS @ 200 ppm, T_{10} - Sucrose @ 2 % + $NaOCl_2$ @ 25 ppm, T_{11}- Sucrose @ 2 % + $NaOCl_2$ @ 50 ppm, T_{12} - Sucrose @ 2 % + Ca $(OCl)_2$ @ 25 ppm, T_{13} - Sucrose @ 2 % + Ca $(OCl)_2$ @ 50 ppm and T_{14} - Control (Distilled water).

Table 4.2.1. Effect of sucrose and antioxidants on water uptake (g flower^{-1}) of gypsophila Cv. Star World

Treatments (T)	**water uptake (g flower^{-1})**					
	Days					
	1	**3**	**5**	**7**	**9**	**Mean**
T_1 Sucrose 2 %	16.3	15.3	13.6	11.3	10.3	13.36 ^{cd}
T_2 Ascorbic acid 100 ppm (AA 100 ppm)	16.6	15.4	13.3	12.3	10.3	13.58 ^{cd}
T_3 Ascorbic acid 200 ppm (AA 200 ppm)	15.3	14.6	14	13.3	12.6	13.96 ^{cd}
T_4 Potassium meta bisulphate 100 ppm (KMS 100 ppm)	19.3	16.3	13.6	11	10.6	14.16 ^{cd}
T_5 Potassium meta bisulphate 200 ppm (KMS 200 ppm)	23	22.6	20.6	19.3	17.6	20.62 ^{c}
T_6 Calcium chloride 25 ppm ($CaCl_2$ 25 ppm)	14	13.3	12	11.6	10.6	12.30 ^{cd}
T_7 Calcium chloride 50 ppm ($CaCl_2$ 50 ppm)	14.3	14	13	12.6	11.6	13.10 ^{cd}
T_8 Sucrose 2 % + AA 100 ppm	27.6	26.3	24.6	20	18.3	23.36 ^{bc}
T_9 Sucrose 2 % + AA 200 ppm	28.6	26.6	24	23.6	21.6	24.88 ^{ab}
T_{10} Sucrose 2 % + KMS 100 ppm	35	33.6	30.3	27.6	24.3	30.16 ^{a}
T_{11} Sucrose 2 % + KMS 200 ppm	35.6	34.3	31.6	29	26.6	31.42^{a}
T_{12} Sucrose 2 % + CaCl2 25 ppm	26	24.6	22.3	20	18.6	22.30 ^{bc}
T_{13} Sucrose 2 % + CaCl2 50 ppm	26.6	24.3	22.6	20.3	18.6	22.48 ^{bc}
T_{14} Control (Distilled water)	13.6	11.6	10.6	9.4	9.3	10.90 ^{d}
S.Em	2.07					
CD (p = 0.05)	5.81					

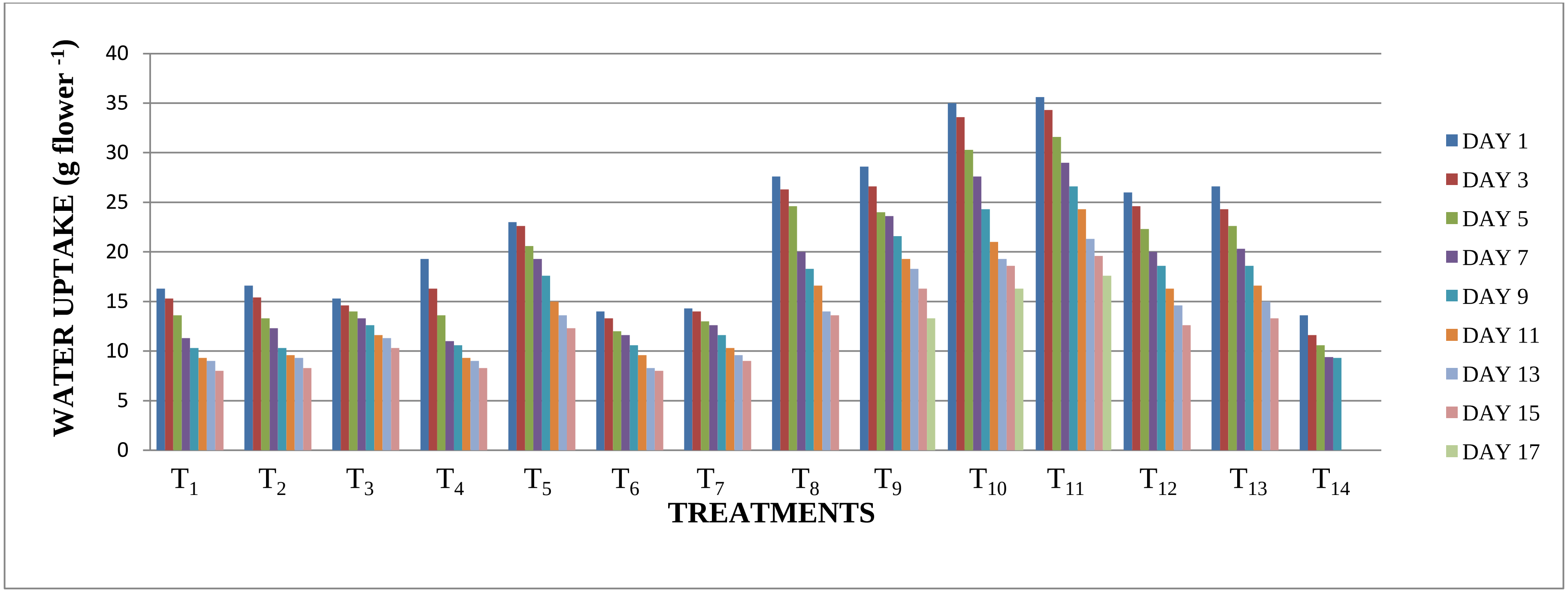

Fig.4.2.1. Effect of sucrose and antioxidants on water uptake (g flower $^{-1}$) of gypsophila Cv. Star World under

T_1 - sucrose @ 2%, T_2 - Ascorbic acid @ 100 ppm, T_3 - Ascorbic acid @ 200 ppm, T_4 - KMS @ 100 ppm, T_5 - KMS @ 200 ppm, T_6 - $CaCl_2$ @ 25 ppm, T_7 - $CaCl_2$ @ 50 ppm, T_8 - Sucrose @ 2 % + AA @ 100 ppm, T_9 -Sucrose @ 2 % + AA @ 200 ppm, T_{10} - Sucrose @ 2 % + KMS @ 100 ppm, T_{11}- Sucrose @ 2 % + KMS @ 200 ppm, T_{12} - Sucrose @ 2 % + $CaCl_2$ @ 25 ppm, T_{13} - Sucrose @ 2 % + $CaCl_2$ @ 50 ppm and T_{14} - Control (Distilled water).

followed by T_{10} (30.16 g flower^{-1}) and T_9 treatments (24.88 g flower^{-1}) and were comparable with each other, whereas it was lowest in T_{14} treatment (control) (10.90 g flower^{-1}).

The highest water uptake in T_9 treatment was due to the presence of sucrose in the vase solution, which acts as carbohydrate source, decreased the water potential (Halevy and Mayak, 1974) and improved the water uptake (Kofranek and Halevy, 1976). The exact reason for KMS on increased WU was unknown as on today. Similar results were also reported by Laksminarayana (2016) in gladiolus.

4.2.2. Transpirational loss of water (TLW) (g. flower^{-1})

The data recorded on changes in TLW during vase life period of cut gypsophila Cv. Star World treated with antioxidant treatments are presented in the table 4.2.2.

Significant difference was observed among the treatments on this parameter. The T_{11} treatment (sucrose @ 2 % + KMS @ 200 ppm) recorded the highest TLW (35.02 g flower^{-1}), followed by T_{10} (32.96 g flower^{-1}), T_9 (27.72 g flower^{-1}) and T_8 treatments (26.84 g flower^{-1}) and they were statistically non-significant with each other, whereas it was lowest in T_{14} treatment (control) (10.52 g flower^{-1}) .

The highest TLW in T_{11} treatment was due to maximum water uptake of this treatment as compared to other treatments. The present findings are in line with the reports of Lakshminarayana (2015) in gladiolus who reported that T_{13} treatment (Sucrose 5 % + KMS 200 ppm) were observed maximum transpirational loss of water as compared to other treatments.

4.2.3 Optical density of vase solution (ODVS) (nm)

The results related to ODVS during vase life period of cut gypsophila Cv. Star World treated with antioxidant treatments are presented in the table 4.2.3.

Table 4.2.2. Effect of sucrose and antioxidants on transpirational loss of water (g flower^{-1}) of gypsophila Cv. Star World

Treatments (T)	Transpirational loss of water (g flower^{-1})					
	Days					
	1	3	5	7	9	Mean
T_1 Sucrose 2 %	14	13.6	12.6	12.3	11	12.70 ^{de}
T_2 Ascorbic acid 100 ppm (AA 100 ppm)	27	23.6	20.3	18	16.3	21.04 ^{bc}
T_3 Ascorbic acid 200 ppm (AA 200 ppm)	27	26	23.6	20.3	17	22.78 ^{bc}
T_4 Potassium meta bisulphate 100 ppm (KMS 100 ppm)	30.6	27.3	24	21.6	19.4	24.58 ^{bc}
T_5 Potassium meta bisulphate 200 ppm (KMS 200 ppm)	33	28.3	24.3	20.6	17	24.64 ^{bc}
T_6 Calcium chloride 25 ppm ($CaCl_2$ 25 ppm)	25.6	20.3	16.3	15.3	14	18.30 ^{cd}
T_7 Calcium chloride 50 ppm ($CaCl_2$ 50 ppm)	27	24.3	20	18.6	13.3	20.64 ^{cd}
T_8 Sucrose 2 % + AA 100 ppm	31	29.3	27	24.6	22.3	26.84 ^{ab}
T_9 Sucrose 2 % + AA 200 ppm	34	31.4	28.3	24.6	20.3	27.72 ^{a}
T_{10} Sucrose 2 % + KMS 100 ppm	40	37.3	33.3	28.6	25.6	32.96 ^{a}
T_{11} Sucrose 2 % + KMS 200 ppm	40.6	38.6	36.3	32.3	27.3	35.02 ^{a}
T_{12} Sucrose 2 % + $CaCl_2$ 25 ppm	30.3	28.6	25.3	21.6	18.6	24.88 ^{bc}
T_{13} Sucrose 2 % + $CaCl_2$ 50 ppm	32.3	28.6	26	22.4	19.3	25.72 ^{b}
T_{14} Control (Distilled water)	12.6	11.3	10.4	9.3	9	10.52 ^{e}
S.Em	2.85					
CD (p = 0.05)	7.99					

Table 4.2.3. Effect of sucrose and antioxidants on optical density of vase solution (480nm) of gypsophila Cv. Star World

Treatments (T)	**Optical density of vase solution (480nm)**					
	Days					
	1	**3**	**5**	**7**	**9**	**Mean**
$\mathbf{T_1}$ Sucrose 2 %	0.088	0.127	0.169	0.195	0.236	0.163 [d]
$\mathbf{T_2}$ Ascorbic acid 100 ppm (AA 100 ppm)	0.074	0.113	0.128	0.152	0.164	0.126 [b]
$\mathbf{T_3}$ Ascorbic acid 200 ppm (AA 200 ppm)	0.082	0.111	0.115	0.119	0.148	0.115[ab]
$\mathbf{T_4}$ Potassium meta bisulphate 100 ppm (KMS 100 ppm)	0.086	0.094	0.102	0.114	0.123	0.104 [a]
$\mathbf{T_5}$ Potassium meta bisulphate 200 ppm (KMS 200 ppm)	0.032	0.075	0.115	0.123	0.135	0.096[a]
$\mathbf{T_6}$ Calcium chloride 25 ppm ($CaCl_2$ 25 ppm)	0.108	0.121	0.182	0.191	0.205	0.161 [c]
$\mathbf{T_7}$ Calcium chloride 50 ppm ($CaCl_2$ 50 ppm)	0.112	0.123	0.156	0.161	0.185	0.147 [bc]
$\mathbf{T_8}$ Sucrose 2 % + AA 100 ppm	0.049	0.053	0.078	0.096	0.109	0.077 [a]
$\mathbf{T_9}$ Sucrose 2 % + AA 200 ppm	0.039	0.063	0.068	0.091	0.108	0.074 [a]
$\mathbf{T_{10}}$ Sucrose 2 % + KMS 100 ppm	0.034	0.043	0.054	0.083	0.097	0.062 [a]
$\mathbf{T_{11}}$ Sucrose 2 % + KMS 200 ppm	0.018	0.027	0.043	0.058	0.074	0.044 [a]
$\mathbf{T_{12}}$ Sucrose 2 % + $CaCl_2$ 25 ppm	0.047	0.071	0.094	0.113	0.142	0.093 [a]
$\mathbf{T_{13}}$ Sucrose 2 % + $CaCl_2$ 50 ppm	0.049	0.068	0.074	0.099	0.107	0.079 [a]
$\mathbf{T_{14}}$ Control (Distilled water)	0.113	0.149	0.172	0.194	0.202	0.166 [e]
S.Em	0.024					
CD (p = 0.05)	0.068					

From the data it is clear that, there was significant differences observed among the treatments on ODVS. Among the treatments, T_{11} treatment (sucrose @ 2 % + KMS @ 200 ppm) recorded the lowest value (0.044 nm) which was on par with T_{10} (0.062 nm), T_9 (0.074 nm), T_8 (0.077 nm), T_{13} (0.079 nm), T_{12} (0.093 nm), T_5 (0.096 nm), T_4 (0.104 nm) and T_3 treatments (0.115 nm), while it was significantly highest in T_{14} treatment (control) (0.166 nm).

The lowest ODVS in T_{11} treatment might be due to low bacterial count as this treatment registered maximum water up take and highest transpirational loss of water than other treatments. There was a positive correlation between the number of bacteria and water conductivity in the stem of cut flower (Van *et al.*, 1991).

4.2.4 Vase life (days)

Data recorded on vase life of cut gypsophila Cv. Star World held in different antioxidant solutions are presented in table 4.2.4. and depicted in the fig. 4.2.2.

All antioxidant treatments differed significantly on vase life of cut gypsophila. The highest vase life was recorded in T_{11} treatment (sucrose @ 2 % + KMS @ 200 ppm) (16.83 days) (Plate 4) and it was comparable with T_{10} (16.2 days) (Plate 5), T_9 (16 days), T_8 (14.2 days), T_{13} (14 days), T_{12} (13.7 days) and T_5 treatments (13.5 days), whereas significantly lowest vase life was registered with T_{14} treatment (control) (8.83 days).

The highest vase life was recorded in T_{11} treatment was due to the same treatment registered the maximum WU, TLW and minimum ODVS than other treatments. The other reason might be due to the addition of sucrose to the solution reduced the moisture stress in cut flowers by better water relations compared to other treatments. It was also due to the synergetic effect of KMS in holding solution acting as preservative and antioxidant reducing lower microbial growth and better vase life.

Table 4.2.4. Effect of sucrose and antioxidants on vase life of flowers (days) of gypsophila Cv. Star World

Treatments (T)	Vase life (days)
$\mathbf{T_1}$ Sucrose 2 %	12 [de]
$\mathbf{T_2}$ Ascorbic acid 100 ppm (AA 100 ppm)	12.3 [c]
$\mathbf{T_3}$ Ascorbic acid 200 ppm (AA 200 ppm)	12.5 [b]
$\mathbf{T_4}$ Potassium meta bisulphate 100 ppm (KMS 100 ppm)	12.7 [b]
$\mathbf{T_5}$ Potassium meta bisulphate 200 ppm (KMS 200 ppm)	13.5 [ab]
$\mathbf{T_6}$ Calcium chloride 25 ppm ($CaCl_2$ 25 ppm)	12.17 [d]
$\mathbf{T_7}$ Calcium chloride 50 ppm ($CaCl_2$ 50 ppm)	12.2 [cd]
$\mathbf{T_8}$ Sucrose 2 % + AA 100 ppm	14.2 [ab]
$\mathbf{T_9}$ Sucrose 2 % + AA 200 ppm	16 [a]
$\mathbf{T_{10}}$ Sucrose 2 % + KMS 100 ppm	16.2 [a]
$\mathbf{T_{11}}$ Sucrose 2 % + KMS 200 ppm	16.83 [a]
$\mathbf{T_{12}}$ Sucrose 2 % + $CaCl_2$ 25 ppm	13.7 [ab]
$\mathbf{T_{13}}$ Sucrose 2 % + $CaCl_2$ 50 ppm	14 [ab]
$\mathbf{T_{14}}$ Control (Distilled water)	8.83 [f]
S.Em	0.57
CD (p = 0.05)	1.67

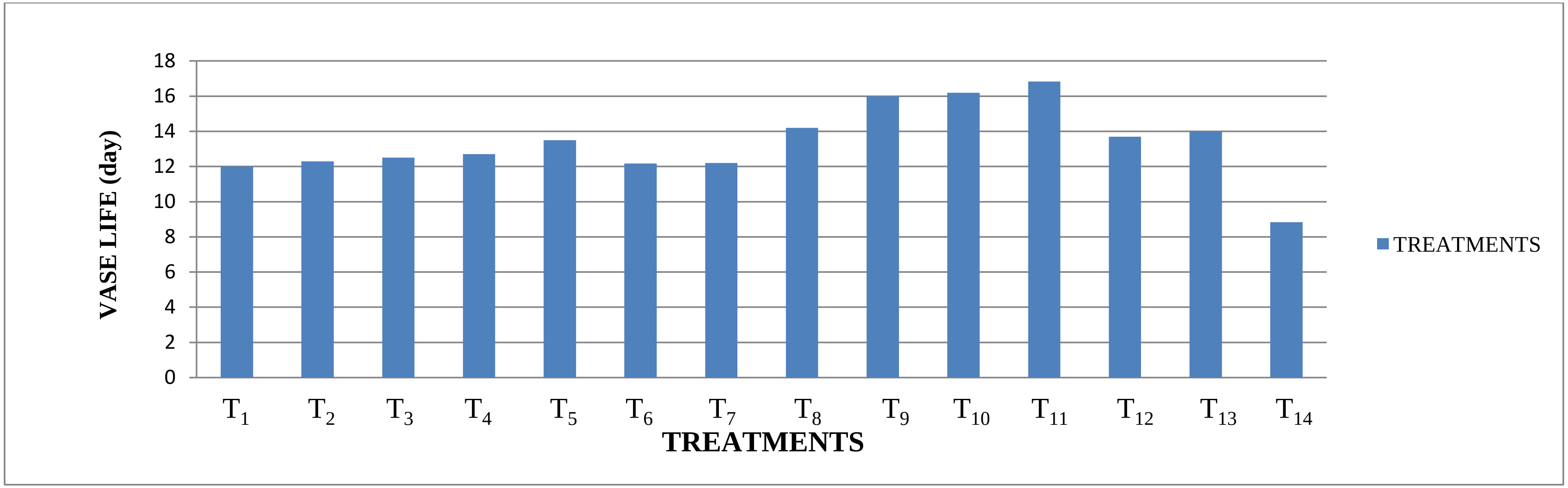

Fig.4.2.2. Effect of sucrose and antioxidants on vase life of flowers (days) of gypsophila Cv. Star World

T_1 - sucrose @ 2%, T_2 - Ascorbic acid @ 100 ppm, T_3 - Ascorbic acid @ 200 ppm, T_4 - KMS @ 100 ppm, T_5 - KMS @ 200 ppm, T_6 - $CaCl_2$ @ 25 ppm, T_7 - $CaCl_2$ @ 50 ppm, T_8 - Sucrose @ 2 % + AA @ 100 ppm, T_9 -Sucrose @ 2 % + AA @ 200 ppm, T_{10} - Sucrose @ 2 % + KMS @ 100 ppm, T_{11}- Sucrose @ 2 % + KMS @ 200 ppm, T_{12} - Sucrose @ 2 % + $CaCl_2$ @ 25 ppm, T_{13} - Sucrose @ 2 % + $CaCl_2$ @ 50 ppm and T_{14} - Control (Distilled water).

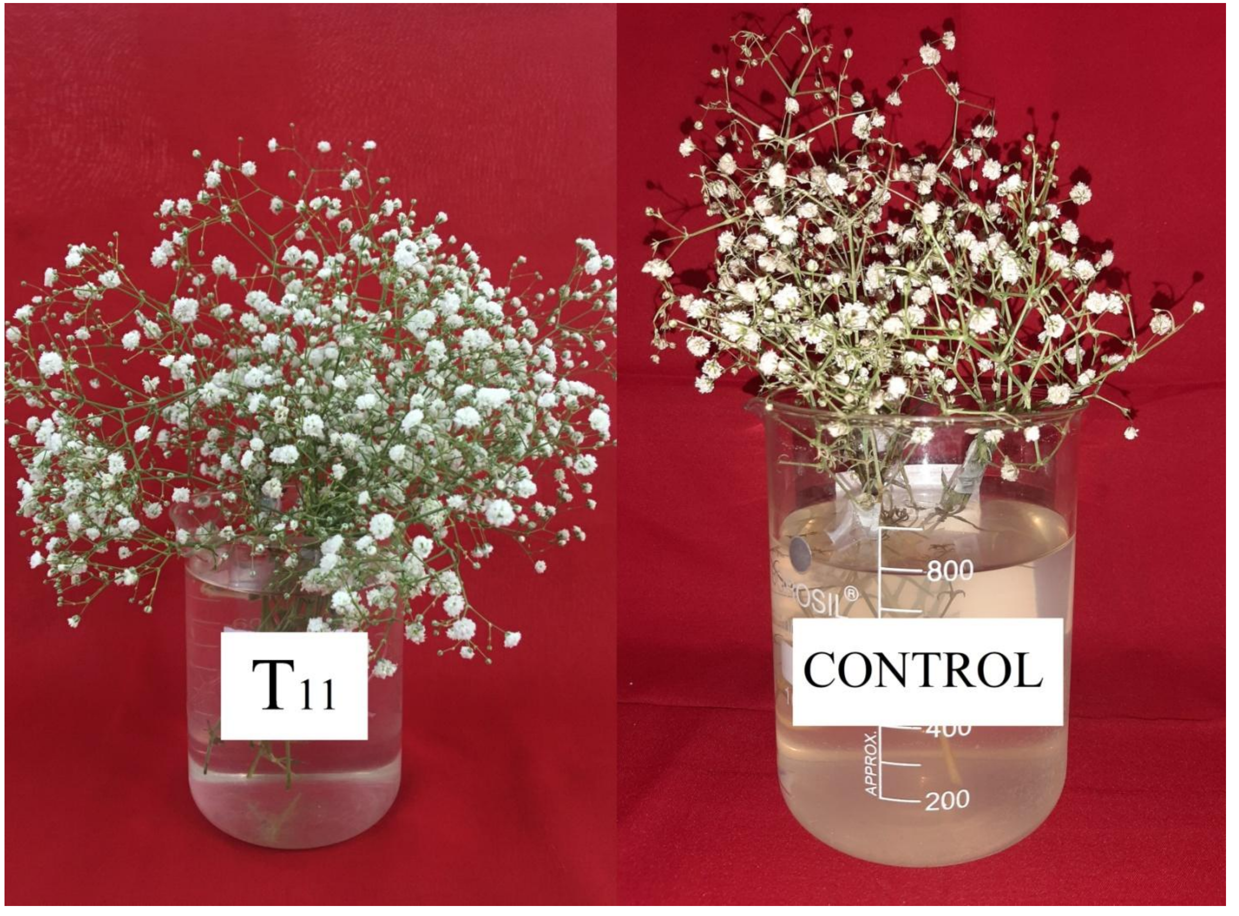

Plate. 4 Comparison of flower quality on 9th day of vase life of T_{11} with control in experiment II

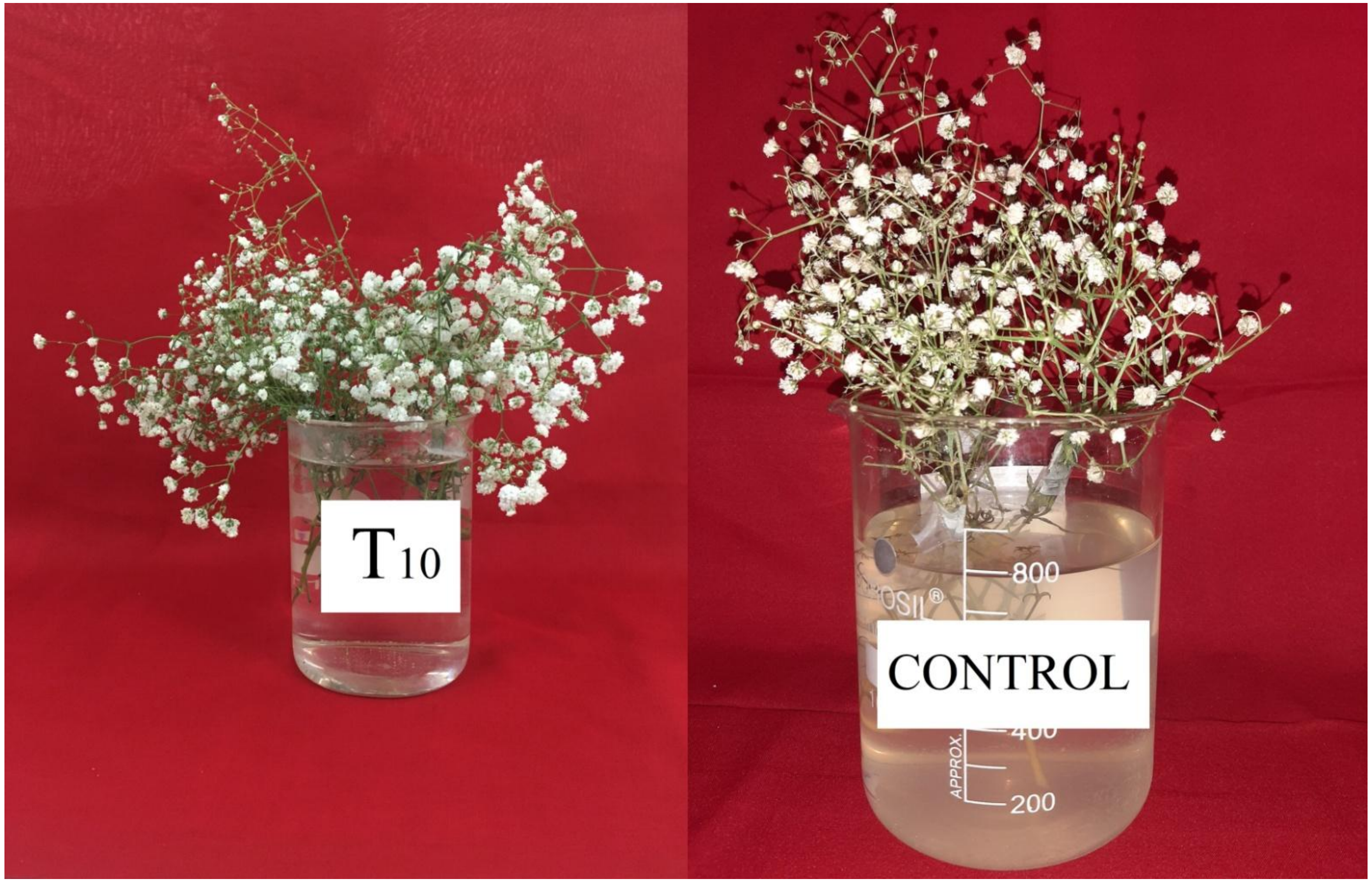

Plate. 5 Comparison of flower quality on 9th day of vase life of T_{10} with control in experiment II

4.2.5 Relative water content (RWC) (%)

The results related to relative water content during vase life period of cut gypsophila Cv. Star World treated with antioxidant treatments are presented in the table 4.2.5.

All treatments had significant difference on relative water content. The highest value was recorded in T_{11} treatment (sucrose @ 2 % + KMS @ 200 ppm) (103.14 %) which was on par with all the treatments, while it was significantly lowest in T_{14} treatment (control) (72.76 %).

The higher relative water content in T_{11} treatment was due to maximum water uptake, transpirational loss of water and fresh weight of this treatment as compared to other treatments.

4.2.6 Physiological change in weight (PCW) (%)

The data on physiological change in weight as influenced by the antioxidant treatments are presented in the table 4.2.6 and depicted in fig. 4.2.3.

There was significant difference observed among the various antioxidant treatments on this parameter. The minimum physiological change in weight was recorded in T_{11} treatment (sucrose @ 2 % + KMS @ 200 ppm) (0.82 %) and it was statistically on par with majority of the treatments, while it was significantly maximum in T_{14} treatment (control) (4.23 %).

The data on physiological change in weight revealed that T_{11} treatment registered minimum value which was due to same reason for the vase life parameter studied.

4.2.7 Water balance (WB) (g. flower^{-1})

The data recorded on changes in water balance during vase life period of cut gypsophila Cv. Star World treated with antioxidant treatments are presented in the table 4.2.7.

Table 4.2.5. Effect of sucrose and antioxidants on relative water content (%) of gypsophila Cv. Star World

Treatments (T)	**Relative water content (%)**					
	Days					
	1	**3**	**5**	**7**	**9**	**Mean**
T_1 Sucrose 2 %	79.6	77.3	79.6	80.9	82.4	79.96 [a]
T_2 Ascorbic acid 100 ppm (AA 100 ppm)	78.9	80.9	82.4	85.3	88	83.10 [a]
T_3 Ascorbic acid 200 ppm (AA 200 ppm)	81.24	83.7	85.2	87.6	84.3	84.41 [a]
T_4 Potassium meta bisulphate 100 ppm (KMS 100 ppm)	80.5	82.7	84.8	86.2	87.9	84.42 [a]
T_5 Potassium meta bisulphate 200 ppm (KMS 200 ppm)	80.3	83.2	85.4	89.7	90.1	85.74 [a]
T_6 Calcium chloride 25 ppm ($CaCl_2$ 25 ppm)	75.6	79.4	80.6	81.8	82.7	80.02 [a]
T_7 Calcium chloride 50 ppm ($CaCl_2$ 50 ppm)	75.4	78.9	80.5	82.7	85.3	80.56 [a]
T_8 Sucrose 2 % + AA 100 ppm	83.4	84.6	88.5	93.2	95.6	89.06 [a]
T_9 Sucrose 2 % + AA 200 ppm	85.6	89.4	94.3	96.7	100.2	93.24 [a]
T_{10} Sucrose 2 % + KMS 100 ppm	89	91.3	94.7	98.3	102	95.06 [a]
T_{11} Sucrose 2 % + KMS 200 ppm	96.2	98.5	101.3	107.6	112.1	103.14 [a]
T_{12} Sucrose 2 % + $CaCl_2$ 25 ppm	82.7	84.7	86.6	89.3	93.7	87.40 [a]
T_{13} Sucrose 2 % + $CaCl_2$ 50 ppm	81.6	83.7	86.8	92.3	96.1	88.01 [a]
T_{14} Control (Distilled water)	70.2	73.6	80.4	71.3	68.3	72.76 [b]
S.Em	8.69					
CD (p = 0.05)	24.41					

Table 4.2.6. Effect of sucrose and antioxidants on physiological change in weight (%) of gypsophila Cv. Star World

Treatments (T)	Physiological change in weight (%)					
	Days					
	1	**3**	**5**	**7**	**9**	**Mean**
T_1 Sucrose 2 %	0.54	0.88	1.05	2.3	2.95	1.54 [bc]
T_2 Ascorbic acid 100 ppm (AA 100 ppm)	0.74	1.34	1.78	2.51	2.76	1.83 [bc]
T_3 Ascorbic acid 200 ppm (AA 200 ppm)	0.62	0.98	1.67	2.05	2.71	1.61 [bc]
T_4 Potassium meta bisulphate 100 ppm (KMS 100 ppm)	0.37	0.76	1.09	1.36	3.61	1.50 [bc]
T_5 Potassium meta bisulphate 200 ppm (KMS 200 ppm)	0.57	0.74	1.09	2.23	2.87	1.50 [bc]
T_6 Calcium chloride 25 ppm ($CaCl_2$ 25 ppm)	0.85	1.04	2.37	4.51	6.73	3.10 [c]
T_7 Calcium chloride 50 ppm ($CaCl_2$ 50 ppm)	0.77	0.95	1.47	2.63	5.01	2.17 [bc]
T_8 Sucrose 2 % + AA 100 ppm	0.59	0.86	1.23	1.66	2.57	1.38 [bc]
T_9 Sucrose 2 % + AA 200 ppm	0.43	0.79	0.99	1.76	2.78	1.35 [bc]
T_{10} Sucrose 2 % + KMS 100 ppm	0.34	0.54	0.98	1.44	2.05	1.07 [b]
T_{11} Sucrose 2 % + KMS 200 ppm	0.11	0.43	0.74	1.8	1.03	0.82 [a]
T_{12} Sucrose 2 % + $CaCl_2$ 25 ppm	0.64	0.76	1.29	1.98	2.61	1.46 [bc]
T_{13} Sucrose 2 % + $CaCl_2$ 50 ppm	0.51	0.64	0.98	1.53	3.6	1.45 [bc]
T_{14} Control (Distilled water)	1.43	2.65	3.76	5.8	7.51	4.23 [c]
S.Em	0.39					
CD (p = 0.05)	1.10					

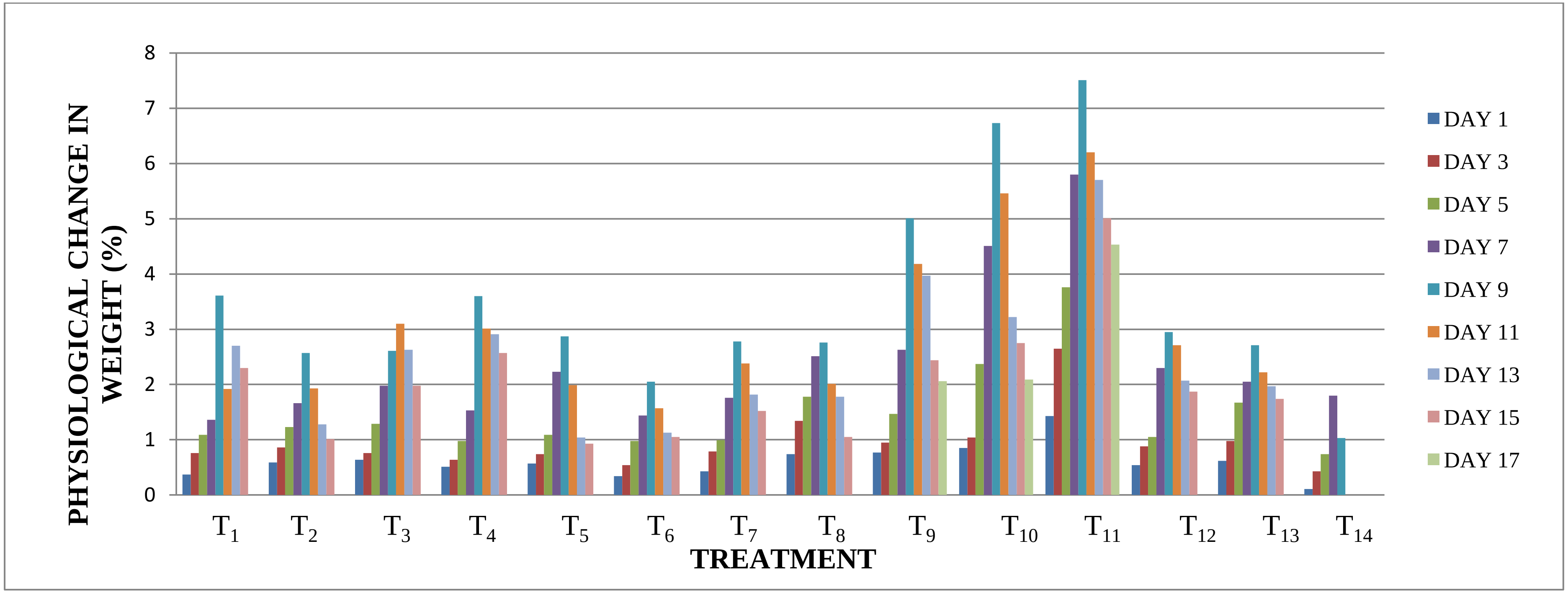

Fig. 4.2.3. Effect of sucrose and antioxidants on physiological change in weight (%) of gypsophila Cv. Star World

T_1 - sucrose @ 2%, T_2 - Ascorbic acid @ 100 ppm, T_3 - Ascorbic acid @ 200 ppm, T_4 - KMS @ 100 ppm, T_5 - KMS @ 200 ppm, T_6 - $CaCl_2$ @ 25 ppm, T_7 - $CaCl_2$ @ 50 ppm, T_8 - Sucrose @ 2 % + AA @ 100 ppm, T_9 -Sucrose @ 2 % + AA @ 200 ppm, T_{10} - Sucrose @ 2 % + KMS @ 100 ppm, T_{11}- Sucrose @ 2 % + KMS @ 200 ppm, T_{12} - Sucrose @ 2 % + $CaCl_2$ @ 25 ppm, T_{13} - Sucrose @ 2 % + $CaCl_2$ @ 50 ppm and T_{14} - Control (Distilled water).

Table 4.2.7. Effect of sucrose and antioxidants on water balance (g flower^{-1}) of gypsophila Cv. Star World

Treatments (T)	Water balance (g flower^{-1})					
	Days					
	1	3	5	7	9	Mean
T_1 Sucrose 2 %	2.3	1.7	1	-1	-0.7	0.66^{a}
T_2 Ascorbic acid 100 ppm (AA 100 ppm)	-10.4	-8.2	-7	-5.7	-6	-7.46^{cd}
T_3 Ascorbic acid 200 ppm (AA 200 ppm)	-12	-11.4	-9.6	-7	-4.4	-8.88^{d}
T_4 Potassium meta bisulphate 100 ppm (KMS 100 ppm)	-11.3	-11	-10.4	-10.6	-8.8	-10.42^{e}
T_5 Potassium meta bisulphate 200 ppm (KMS 200 ppm)	-10	-6	-3.7	-1.3	0.6	-4.08^{b}
T_6 Calcium chloride 25 ppm ($CaCl_2$ 25 ppm)	-11.6	-7	-4.3	-3.7	-3.4	-6^{c}
T_7 Calcium chloride 50 ppm ($CaCl_2$ 50 ppm)	-12.7	-10.3	-7	-6	-1.7	-7.54^{cd}
T_8 Sucrose 2 % + AA 100 ppm	-3.4	-3	-2.4	-4.6	-2	-3.08^{ab}
T_9 Sucrose 2 % + AA 200 ppm	-5.4	-4.8	-4.3	-1	1.3	-2.84^{a}
T_{10} Sucrose 2 % + KMS 100 ppm	-5	-4	-3	-1	-1.3	-2.86^{a}
T_{11} Sucrose 2 % + KMS 200 ppm	-5	-4.3	-4.7	-3.3	-0.7	-3.60^{ab}
T_{12} Sucrose 2 % + $CaCl_2$ 25 ppm	-4.3	-4	-3	-1.6	1	-2.38^{a}
T_{13} Sucrose 2 % + $CaCl_2$ 50 ppm	-5.7	-4.3	-3.4	-2.1	-0.7	-3.24^{ab}
T_{14} Control (Distilled water)	1	0.3	0.2	0.1	0.3	0.30^{a}
S.Em	1.09					
CD (p = 0.05)	3.08					

Significant differences were observed among the treatments on water balance. Among the treatments, T_1 treatment (sucrose @ 2 %) recorded the highest water balance (0.66 g $flower^{-1}$) which was on par with T_{14} (control) (0.30 g $flower^{-1}$), T_{12} (-2.38 g $flower^{-1}$), T_9 (-2.84 g $flower^{-1}$), T_{10} (-2.86 g $flower^{-1}$), T_8 (-3.08 g $flower^{-1}$), T_{13} (-3.24 g $flower^{-1}$) and T_{11} treatments (-3.60 g $flower^{-1}$), whereas significantly lowest in T_4 treatment (KMS @ 100 ppm) (-10.42 g $flower^{-1}$).

From the table 4.2.7, it is clear that maximum water balance was recorded in T_1 treatment and was on par with T_{11} treatment which was due to more water uptake and TLW than other treatments.

4.2.8 Fresh weight (g. $flower^{-1}$)

The results related to changes in fresh weight during vase life period of cut gypsophila Cv. Star World as affected by the antioxidant treatments are presented in the table 4.2.8. and depicted in the fig. 4.2.4.

All antioxidant treatments differed significantly on fresh weight. The highest value was recorded in T_{11} treatment (sucrose @ 2 % + KMS @ 200 ppm) (16.8 g $flower^{-1}$), followed by T_{10} (16.6 g $flower^{-1}$), T_9 (16.53 g $flower^{-1}$) and T_8 treatments (16.4 g $flower^{-1}$) and were on par with each other, whereas lowest value was recorded in T_{14} treatment (control) (11.07 g $flower^{-1}$).

It is cleared that, the highest value of fresh weight was recorded in T_{11} treatment (sucrose @ 2 % + KMS @ 200 ppm) which might be due to the same treatment registered the minimum value of physiological change in weight, led to more fresh weight than other treatments

4.2.9 Dry weight (g. $flower^{-1}$)

The data pertaining to changes in dry weight during vase life period of cut gypsophila Cv. Star World treated with various antioxidant treatments are presented in the table 4.2.9.

Table 4.2.9. represents that maximum dry weight was recorded in T_{11} treatment (sucrose @ 2 % + KMS @ 200 ppm) (8.7 g $flower^{-1}$) and

Table 4.2.8. Effect of sucrose and antioxidants on fresh weight (g flower^{-1}) of gypsophila Cv. Star World

Treatments (T)	Fresh weight (g)
T_1 Sucrose 2 %	14.2 [ab]
T_2 Ascorbic acid 100 ppm (AA 100 ppm)	12.3 [ab]
T_3 Ascorbic acid 200 ppm (AA 200 ppm)	15.73 [a]
T_4 Potassium meta bisulphate 100 ppm (KMS 100 ppm)	15.8 [a]
T_5 Potassium meta bisulphate 200 ppm (KMS 200 ppm)	15.93 [a]
T_6 Calcium chloride 25 ppm ($CaCl_2$ 25 ppm)	16.03 [a]
T_7 Calcium chloride 50 ppm ($CaCl_2$ 50 ppm)	15.4 [a]
T_8 Sucrose 2 % + AA 100 ppm	16.4 [a]
T_9 Sucrose 2 % + AA 200 ppm	16.53 [a]
T_{10} Sucrose 2 % + KMS 100 ppm	16.6 [a]
T_{11} Sucrose 2 % + KMS 200 ppm	16.8 [a]
T_{12} Sucrose 2 % + $CaCl_2$ 25 ppm	16.13 [a]
T_{13} Sucrose 2 % + $CaCl_2$ 50 ppm	16.3 [a]
T_{14} Control (Distilled water)	11.07 [b]
S.Em	0.52
CD (p = 0.05)	1.51

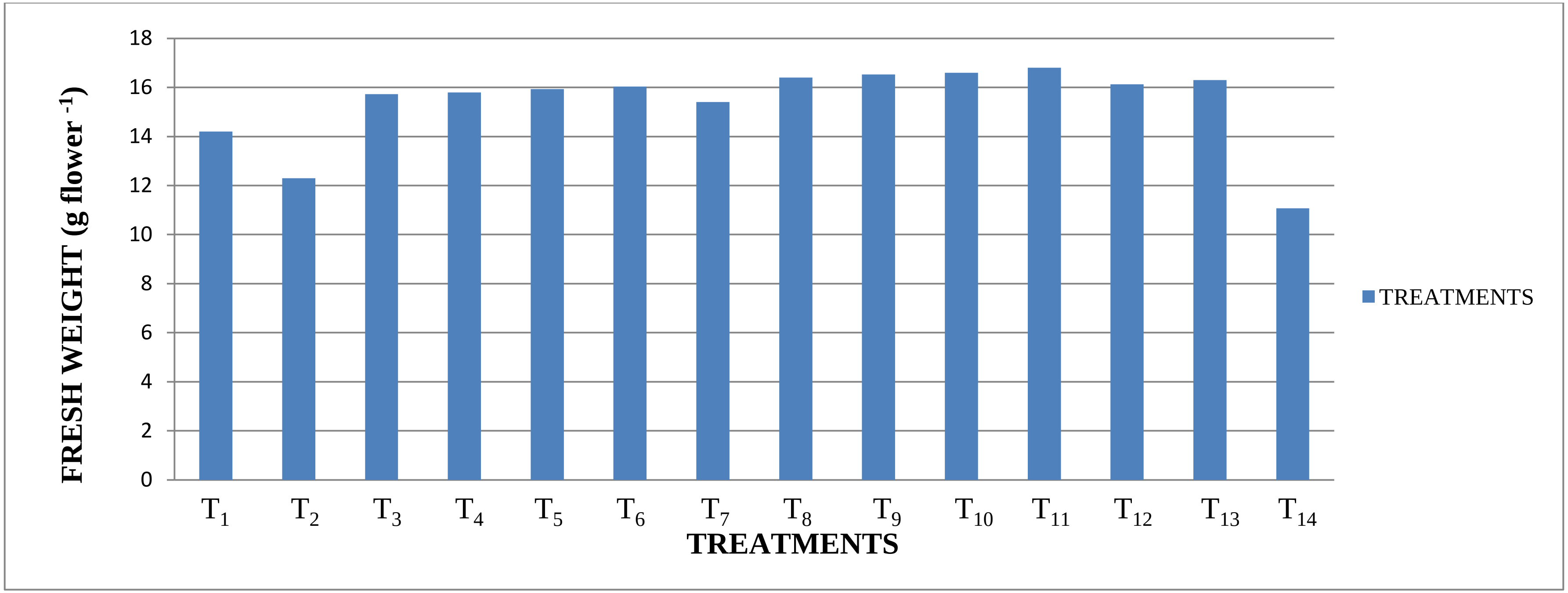

Fig. 4.2.4. Effect of sucrose and antioxidants on fresh weight (g flower $^{-1}$) of gypsophila Cv. Star World

T_1 - sucrose @ 2%, T_2 - Ascorbic acid @ 100 ppm, T_3 - Ascorbic acid @ 200 ppm, T_4 - KMS @ 100 ppm, T_5 - KMS @ 200 ppm, T_6 - $CaCl_2$ @ 25 ppm, T_7 - $CaCl_2$ @ 50 ppm, T_8 - Sucrose @ 2 % + AA @ 100 ppm, T_9 -Sucrose @ 2 % + AA @ 200 ppm, T_{10} - Sucrose @ 2 % + KMS @ 100 ppm, T_{11}- Sucrose @ 2 % + KMS @ 200 ppm, T_{12} - Sucrose @ 2 % + $CaCl_2$ @ 25 ppm, T_{13} - Sucrose @ 2 % + $CaCl_2$ @ 50 ppm and T_{14} - Control (Distilled water).

Table 4.2.9. Effect of sucrose and antioxidants on dry weight (g $flower^{-1}$) of gypsophila Cv. Star World

Treatments (T)	Dry weight (g)
T_1 Sucrose 2 %	7.00 [cd]
T_2 Ascorbic acid 100 ppm (AA 100 ppm)	7.20[cd]
T_3 Ascorbic acid 200 ppm (AA 200 ppm)	7.30 [c]
T_4 Potassium meta bisulphate 100 ppm (KMS 100 ppm)	7.40 [bc]
T_5 Potassium meta bisulphate 200 ppm (KMS 200 ppm)	7.47 [b]
T_6 Calcium chloride 25 ppm ($CaCl_2$ 25 ppm)	7.07 [cd]
T_7 Calcium chloride 50 ppm ($CaCl_2$ 50 ppm)	7.13 [cd]
T_8 Sucrose 2 % + AA 100 ppm	7.73 [a]
T_9 Sucrose 2 % + AA 200 ppm	8.40 [a]
T_{10} Sucrose 2 % + KMS 100 ppm	8.60 [a]
T_{11} Sucrose 2 % + KMS 200 ppm	8.70 [a]
T_{12} Sucrose 2 % + $CaCl_2$ 25 ppm	7.53 [ab]
T_{13} Sucrose 2 % + $CaCl_2$ 50 ppm	7.67 [a]
T_{14} Control (Distilled water)	6.93 [d]
S.Em	0.39
CD (p = 0.05)	1.14

it was non significant with T_{10} (8.6 g flower^{-1}), T_9 (8.4 g flower^{-1}), T_8 (7.73 g flower^{-1}), T_{13} (7.67 g flower^{-1}) and T_{12} treatments (7.53 g flower^{-1}), while lowest dry weight was recorded in T_{14} treatment (control) (6.93 g flower^{-1}) and was on par with T_1 (7 g flower^{-1}), T_2 (7.2 g flower^{-1}), T_6 (7.07 g flower^{-1}) and T_7 treatments (7.13 g flower^{-1}).

The highest dry weight in T_{11} treatment was due to the same treatment registered the maximum fresh weight over other treatments.

4.2.10 Water uptake to water loss ratio

The data on water uptake to water loss ratio during vase life period of cut gypsophila Cv. Star World as influenced by various antioxidant treatments are presented in the table 4.2.10. and fig. 4.2.5.

Significant differences were observed among the antioxidant treatments with respect to water uptake to water loss ratio. The maximum value (1.045) was recorded in T_{11} treatment (sucrose @ 2 % + KMS @ 200 ppm) and it was on par with most of the treatments, whereas minimum value was recorded in T_{14} treatment (KMS @ 100 ppm) (0.570).

The highest water uptake to water loss ratio was recorded in T_{11} treatment which was due to the same treatment registered the highest WU and lowest water loss as compared to the other treatments.

4.3. Effect of sucrose, biocides and antioxidants on vase life of Gypsophila Cv. Star World under ambient conditions.

4.3.1Water uptake (WU) (g.flower^{-1})

The results related to changes in water uptake during vase life period of cut gypsophila Cv. Star World treated with best treatments of experiment I and II are presented in the table 4.3.1.and depicted in the fig. 4.3.1.

The combination treatments differed significantly on WU. Maximum value was recorded in T_1 treatment (sucrose @ 2 % + 8HQS @ 200 ppm + KMS @ 200 ppm) (27.76 g flower^{-1}), followed by T_2 (25.62 g flower^{-1}) and T_3 treatments (21.36 g flower^{-1}) and were comparable with

Table 4.2.10. Effect of sucrose and antioxidants on water uptake to water loss ratio of gypsophila Cv. Star World

Treatments (T)	water uptake to water loss ratio					
	Days					
	1	3	5	7	9	Mean
T_1 Sucrose 2 %	0.877	0.889	0.871	0.898	0.974	0.902 [a]
T_2 Ascorbic acid 100 ppm (AA 100 ppm)	0.615	0.653	0.655	0.683	0.632	0.648 [ab]
T_3 Ascorbic acid 200 ppm (AA 200 ppm)	0.567	0.562	0.593	0.655	0.741	0.624 [c]
T_4 Potassium meta bisulphate 100 ppm (KMS 100 ppm)	0.875	0.901	0.909	0.965	0.949	0.919 [a]
T_5 Potassium meta bisulphate 200 ppm (KMS 200 ppm)	0.697	0.790	0.848	0.937	1.035	0.983 [a]
T_6 Calcium chloride 25 ppm ($CaCl_2$ 25 ppm)	0.547	0.655	0.736	0.758	0.757	0.861 [a]
T_7 Calcium chloride 50 ppm ($CaCl_2$ 50 ppm)	0.529	0.576	0.65	0.677	0.872	0.661 [ab]
T_8 Sucrose 2 % + AA 100 ppm	0.890	0.898	0.911	0.813	0.649	0.832 [a]
T_9 Sucrose 2 % + AA 200 ppm	0.841	0.847	0.848	0.959	1.064	0.912 [a]
T_{10} Sucrose 2 % + KMS 100 ppm	1.079	1.027	1.019	1.011	1.033	1.034 [a]
T_{11} Sucrose 2 % + KMS 200 ppm	1.164	1.125	1.079	0.919	0.936	1.045[a]
T_{12} Sucrose 2 % + $CaCl_2$ 25 ppm	0.858	0.860	0.881	0.926	1	0.905 [a]
T_{13} Sucrose 2 % + $CaCl_2$ 50 ppm	0.824	0.849	0.869	0.906	0.964	0.882 [a]
T_{14} Control (Distilled water)	0.631	0.597	0.567	0.509	0.546	0.570 [d]
S.Em	0.100					
CD (p = 0.05)	0.281					

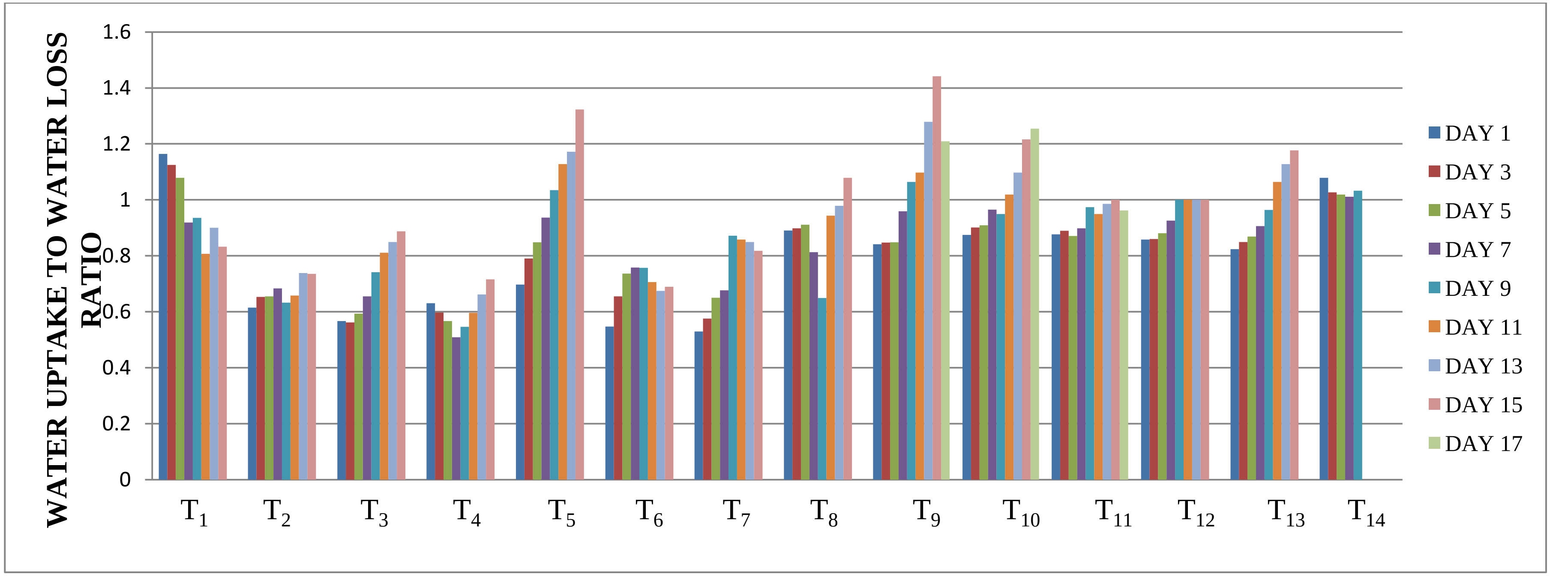

Fig. 4.2.5. Effect of sucrose and antioxidants on water uptake to water loss ratio of gypsophila Cv. Star World

T_1 - sucrose @ 2%, T_2 - Ascorbic acid @ 100 ppm, T_3 - Ascorbic acid @ 200 ppm, T_4 - KMS @ 100 ppm, T_5 - KMS @ 200 ppm, T_6 - $CaCl_2$ @ 25 ppm, T_7 - $CaCl_2$ @ 50 ppm, T_8 - Sucrose @ 2 % + AA @ 100 ppm, T_9 -Sucrose @ 2 % + AA @ 200 ppm, T_{10} - Sucrose @ 2 % + KMS @ 100 ppm, T_{11}- Sucrose @ 2 % + KMS @ 200 ppm, T_{12} - Sucrose @ 2 % + $CaCl_2$ @ 25 ppm, T_{13} - Sucrose @ 2 % + $CaCl_2$ @ 50 ppm and T_{14} - Control (Distilled water).

Table 4.3.1. Effect of sucrose, biocides and antioxidants on water uptake (g flower^{-1}) of gypsophila Cv. Star World

Treatments (T)	Water uptake (g flower^{-1})									
	Days									
	1	3	5	7	9	11	13	15	17	Mean
T_1 Sucrose 2 % + 8HQS 200 ppm + KMS 200 ppm	39	36.3	31.6	29	26.4	24.6	23.3	21	18.6	27.76 ^{a}
T_2 Sucrose 2 % + 8HQS 200 ppm + KMS 100 ppm	34.2	31.6	30.3	28.4	25.6	22.3	21.3	19.3	17.6	25.62 ^{a}
T_3 Sucrose 2 % + 8HQS 100 ppm + KMS 200 ppm	30.6	27.6	24.4	23.6	20.6	19.6	17.6	14.6	13.6	21.36 ^{ab}
T_4 Sucrose 2 % + 8HQS 100 ppm + KMS 100 ppm	29.3	25.6	22.6	19	18.3	15.6	14.3	13.6	12.6	18.99 ^{b}
S.Em	2.03									
CD (p = 0.05)	5.86									

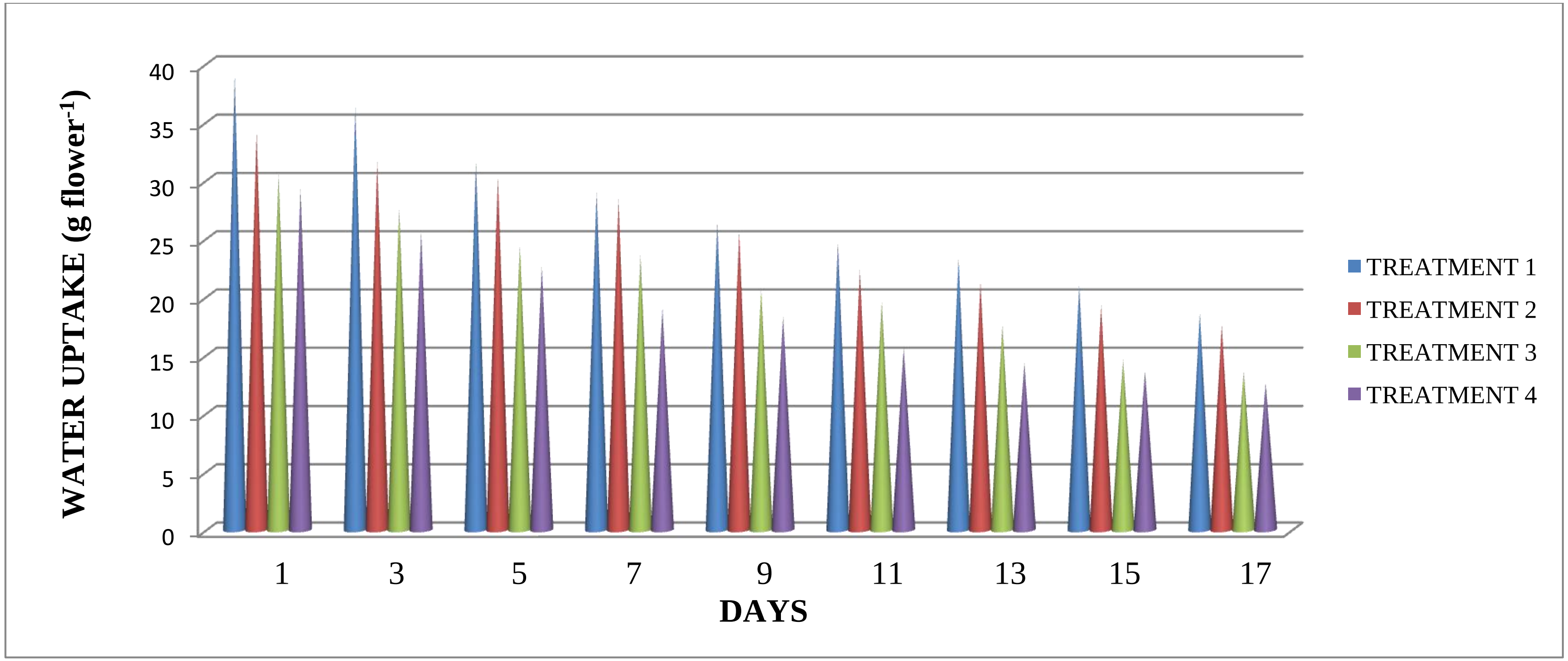

Fig. 4.3.1. Effect of sucrose, biocides and antioxidants on water uptake (g flower^{-1}) of gypsophila Cv. Star World

each other, whereas lowest value was recorded in T_4 treatment (sucrose @ 2 % + 8HQS @ 100 ppm + KMS @ 100 ppm) (18.99 g flower^{-1}).

The highest WU in T_1 treatment might be due to sucrose in vase solution acts as respiratory substrate and enhanced water up take. The increased uptake of solution was due to osmotic concentration and accumulation of sucrose (Pushpendra Kumar and Amit Kumar, 2012). It might have inhibited stem plugging as indicated by the increased water uptake in flower stakes held in 8-HQS (Halve and Mayak, 1981). Similar results were also reported by Lakshminarayana and Prashanth (2020) in gladiolus.

4.3.2. Transpirational loss of water (TLW) (g.flower^{-1})

The data pertaining to changes in TLW during vase life period of cut gypsophila Cv. Star World treated with best treatments of experiment I and II are presented in the table 4.3.2.

All combination treatments were differed significantly with respect to TLW. Among the treatments, T_1 treatment (sucrose @ 2 % + 8HQS @ 200 ppm+ KMS @ 200 ppm) recorded the highest TLW (28.90 g flower^{-1}) which was on par with T_2 (26.07 g flower^{-1}) and T_3 treatments (21.78 g flower^{-1}), while it was lowest in T_4 treatment (sucrose @ 2 % + 8HQS @ 100 ppm + KMS @ 100 ppm) (21.40 g flower^{-1}).

From the data, it is clear that maximum TLW was recorded in T_1 treatment which was due to the higher water up take of this treatment as compared to other treatments. Amith, 2010 reported that when cut flowers of Gerbera Cv. Shangria treated with sucrose and 8-HQS exhibited maximum TLW over other treatments.

4.3.3. Optical density of vase solution (ODVS) (nm)

The data on ODVS during vase life period of cut gypsophila Cv. Star World treated with best treatment combinations of experiment I and II are presented in the table 4.3.3.

Table 4.3.2. Effect sucrose, biocides and antioxidants on transpirational loss of water (g flower^{-1}) of gypsophila Cv. Star World

Treatments (T)	Transpirational loss of water (g flower^{-1})									
	Days									
	1	3	5	7	9	11	13	15	17	Mean
T_1 Sucrose 2 % + 8HQS 200 ppm + KMS 200 ppm	38.6	35.3	33.2	30.6	28.6	25.3	24.6	23.3	20.6	28.90 [a]
T_2 Sucrose 2 % + 8HQS 200 ppm + KMS 100 ppm	35.4	32.6	30.6	27.3	26.3	24.6	22.4	19.6	16	26.07 [a]
T_3 Sucrose 2 % + 8HQS 100 ppm + KMS 200 ppm	31	28.3	25.6	23.3	20.6	19.6	17.6	16.4	13.6	21.78 [ab]
T_4 Sucrose 2 % + 8HQS 100 ppm +KMS 100 ppm	30	27.4	25.6	24.3	22.4	18.3	16.6	15.4	12.6	21.40 [b]
S.Em	1.99									
CD (p = 0.05)	5.78									

Table 4.3.3. Effect sucrose, biocides and antioxidants on optical density of vase solution (480nm) of gypsophila Cv. Star World

Treatments (T)	**Optical density of vase solution (480nm)**									
	Days									
	1	**3**	**5**	**7**	**9**	**11**	**13**	**15**	**17**	**Mean**
T_1 Sucrose 2 % + 8HQS 200 ppm + KMS 200 ppm	0.038	0.045	0.052	0.068	0.074	0.087	0.098	0.106	0.124	0.077 [a]
T_2 Sucrose 2 % + 8HQS 200 ppm + KMS 100 ppm	0.049	0.071	0.078	0.098	0.106	0.115	0.129	0.135	0.149	0.103 [a]
T_3 Sucrose 2 % + 8HQS 100 ppm + KMS 200 ppm	0.054	0.084	0.097	0.104	0.128	0.131	0.148	0.159	0.164	0.119 [a]
T_4 Sucrose 2 % + 8HQS 100 ppm + KMS 100 ppm	0.077	0.086	0.099	0.107	0.134	0.152	0.166	0.173	0.193	1.961 [b]
S.Em	0.013									
CD (p = 0.05)	0.037									

All combination treatments exerted significant differences on ODVS. The lowest value was recorded in T_1 treatment (sucrose @ 2 % + 8HQS @ 200 ppm + KMS @ 200 ppm) (0.077 nm) followed by T_2 (0.103 nm) and T_3 treatments (0.119 nm) and were comparable with each other. While it was significantly highest in T_4 treatment (sucrose @ 2 % + 8HQS @ 100 ppm+ KMS @ 100 ppm) (1.961 nm).

The lowest ODVS in T_1 treatment might be due to more clarity of solution with lowest microbial growth as compared to other treatments. Similar results were also reported by Reddy *et al*. (1996) in tuberose who reported that 8-HQS reduces microorganisms and cause an increase in water uptake and decreases optical density with cut flowers. KMS as antioxidant active in scavenging free radicles and thereby act as preservative for enhancing vase life.

4.3.4 Vase life (days)

The data pertaining to vase life of cut gypsophila Cv. Star World held in different combination treatments are presented in table 4.3.4. and illustrated in the fig. 4.3.2.

There was significant difference observed among the treatments on vase life. The highest vase life (16.98 days) was recorded in T_1 treatment (sucrose @ 2 % + 8HQS @ 200 ppm+ KMS @ 200 ppm) followed by T_2 (15.9 days) and T_3 treatments (15.65 days) and were statistically on par with each other, whereas it was lowest in T_4 treatment (sucrose @ 2 % + 8HQS @ 100 ppm+ KMS @ 100 ppm) (15.35 days).

The highest vase life in T_1 treatment was due to the same treatment registered the maximum water uptake, transpirational loss water and the least ODVS resulted in longer vase life than other treatments. The other reason might be that synergetic effect of 8HQS and KMS resulted in the higher vase life as compared to other treatments, which has similar action. The present findings are comparable with that of Laksminarayana and Prashanth (2020) in gladiolus who reported that the combination effect of floral preservatives not only related the flower water content and

Table 4.3.4. Effect sucrose, biocides and antioxidants on vase life (days) of gypsophila Cv. Star World

Treatments (T)	**Vase life (days)**
$\mathbf{T_1}$ Sucrose 2 % + 8HQS 200 ppm + KMS 200 ppm	16.98 [a]
$\mathbf{T_2}$ Sucrose 2 % + 8HQS 200 ppm + KMS 100 ppm	15.9 [ab]
$\mathbf{T_3}$ Sucrose 2 % + 8HQS 100 ppm + KMS 200 ppm	15.65 [ab]
$\mathbf{T_4}$ Sucrose 2 % + 8HQS 100 ppm + KMS 100 ppm	15.35 [b]
S.Em	0.19
CD (p = 0.05)	0.55

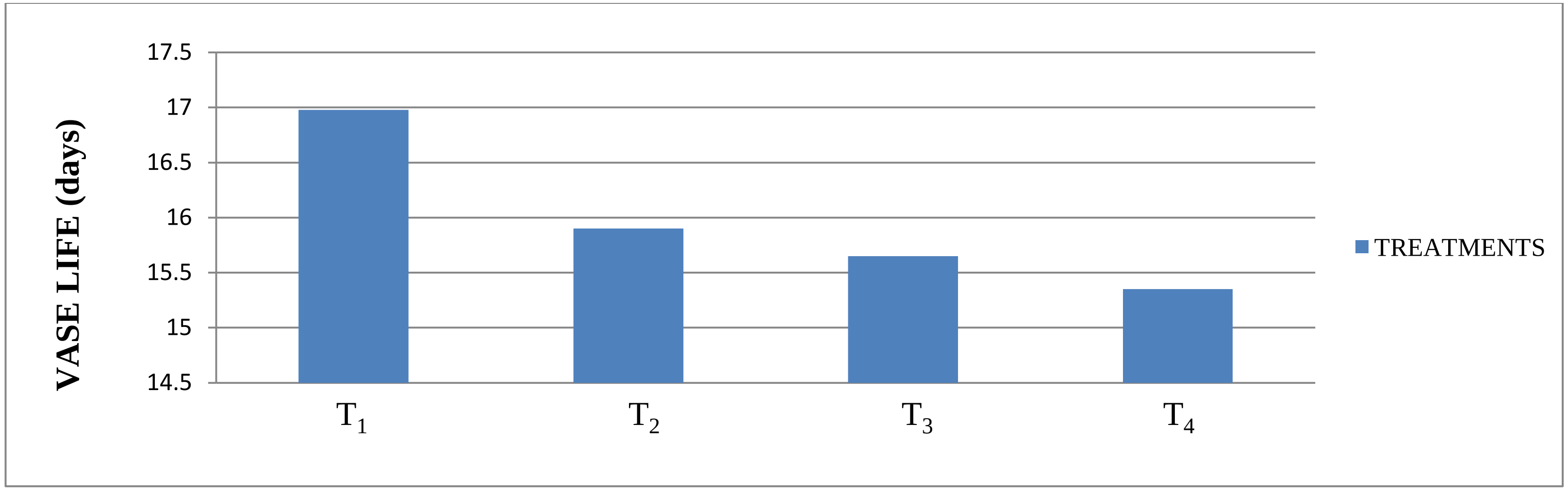

Fig. 4.3.2. Effect sucrose, biocides and antioxidants on vase life (days) of gypsophila Cv. Star World

also maintains chlorophyll, carbohydrates and membrane stability and decreases ethylene production and the antioxidant enzyme activities, with reduced lipid peroxidation, ultimately led to longer vase life.

4.3.5 Relative water content (RWC %)

The data on changes in relative water content during vase life period of gypsophila Cv. Star World held in best treatment combinations of experiment I and II are presented in the table 4.3.5.

From the data it is clear that all treatments showed non significant differences with respect to relative water content.

4.3.6 Physiological change in weight (PCW %)

The results related to changes in physiological weight during vase life period of gypsophila Cv. Star World treated with best treatment combinations of experiment I and II are presented in table 4.3.6. and illustrated in the fig. 4.3.3.

It was observed that, all treatment combinations were differed significantly on physiological change in weight. The lowest value was recorded in T_1 treatment (sucrose @ 2 % + 8HQS @ 200 ppm + KMS @ 200 ppm) (2.60 %) and it was on par with T_2 treatment (3.67 %), while it was highest in T_4 treatment (sucrose @ 2 % + 8HQS @ 100 ppm + KMS @ 100 ppm) (4.99 %) and comparable with T_3 treatment (4.50 %).

The lowest PCW was recorded in T_1 treatment which was due to same reason for the vase life parameter studies. The present investigation was comparable with other reports of Joshi (2012) in gerbera.

4.3.7 Water balance (WB) (g.flower^{-1})

Data recorded on water balance during vase life period of gypsophila Cv. Star World treated with best treatment combinations of biocide and antioxidant solutions are presented in the table 4.3.7.

From the data, it is revealed that there was statistically non significant differences were observed among the treatments on water balance.

Table 4.3.5. Effect of sucrose, biocides and antioxidants on relative water content (%) of gypsophila Cv. Star World

Treatments (T)	**Relative water content (%)**									
	Days									
	1	**3**	**5**	**7**	**9**	**11**	**13**	**15**	**17**	**mean**
T_1 Sucrose 2 % + 8HQS 200 ppm + KMS 200 ppm	90.5	96.4	103.3	108.2	112.6	107.3	102	94.3	87.5	100.23
T_2 Sucrose 2 % + 8HQS 200 ppm + KMS 100 ppm	85	88.4	91.4	95.4	99.6	94.8	89.3	83.9	79.2	89.67
T_3 Sucrose 2 % + 8HQS 100 ppm + KMS 200 ppm	93.2	95.1	101	106.8	111	104.2	96.6	87.3	79.2	86.89
T_4 Sucrose 2 % + 8HQS 100 ppm + KMS 100 ppm	83.8	89.9	96.1	102.9	106.2	99.7	84.4	80.4	77.8	91.24
S.Em	3.054									
CD (p = 0.05)	NS									

Table 4.3.6. Effect of sucrose, biocides and antioxidants on physiological change in weight (%) of gypsophila Cv. Star World

Treatments (T)	Physiological change in weight (%)									
	Days									
	1	**3**	**5**	**7**	**9**	**11**	**13**	**15**	**17**	**mean**
T_1 Sucrose 2 % + 8HQS 200 ppm + KMS 200 ppm	0.958	1.79	2.53	3.06	4.33	3.57	2.89	2.31	1.99	2.60^{a}
T_2 Sucrose 2 % + 8HQS 200 ppm + KMS 100 ppm	1.35	1.90	2.69	4.71	5.49	5.06	4.73	4.07	3	3.67^{ab}
T_3 Sucrose 2 % + 8HQS 100 ppm + KMS 200 ppm	1.79	2.48	4.38	5.42	7.51	6.93	5.41	3.99	2.63	4.50^{b}
T_4 Sucrose 2 % + 8HQS 100 ppm + KMS 100 ppm	2.07	3.54	4.67	7.47	8.49	6.55	5.38	3.72	3.04	4.99^{b}
S.Em	0.57									
CD (p = 0.05)	1.66									

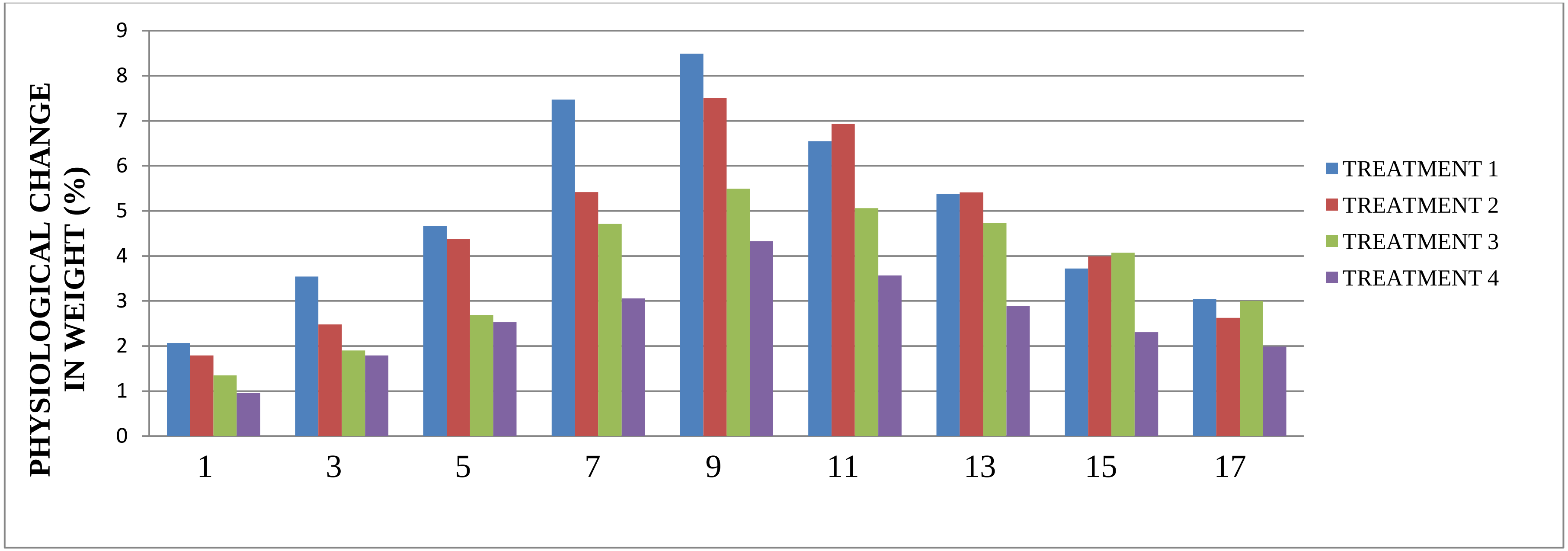

Fig. 4.3.3. Effect of sucrose, biocides and antioxidants on physiological change in weight (%) of gypsophila Cv. Star World

Table 4.3.7. Effect of sucrose, biocides and antioxidants on water balance (g.flower^{-1}) of gypsophila Cv. Star World

Treatments (T)	**Water balance (g.flower^{-1})**									
	Days									
	1	**3**	**5**	**7**	**9**	**11**	**13**	**15**	**17**	**Mean**
T_1 Sucrose 2 % + 8HQS 200 ppm + KMS 200 ppm	0.4	3.54	-1.6	-1.6	-2.2	-0.7	-1.3	-2.3	-2	-0.86
T_2 Sucrose 2 % + 8HQS 200 ppm + KMS 100 ppm	-1.2	-1	-0.3	1.1	-0.7	-2.3	-1.3	-0.3	1.6	-0.49
T_3 Sucrose 2 % + 8HQS 100 ppm + KMS 200 ppm	-0.4	-0.7	-1.2	0.3	0	0.3	-0.3	-1.8	0	-0.42
T_4 Sucrose 2 % + 8HQS 100 ppm + KMS 100 ppm	-0.7	-1.8	-3	-5.3	-4.1	-2.7	-2.6	-1.8	0	-2.29
S.Em	2.189									
CD (p = 0.05)	NS									

4.3.8. Fresh weight (g.flower^{-1})

The data pertaining to fresh weight during vase life period of cut gypsophila Cv. Star World treated with best treatments of experiment I and II are presented in the table 4.3.8 and illustrated in the fig. 4.3.4

All combination treatments differed significantly on this parameter. The highest fresh weight (17.03 g flower^{-1}) was recorded with T_1 treatment (sucrose @ 2 % + 8HQS @ 200 ppm + KMS @ 200 ppm) which was on par with T_2 (15.72 g flower^{-1}) and T_3 treatments (15.33 g flower^{-1}), while it was lowest in T_4 treatment (sucrose @ 2 % + 8HQS @ 100 ppm + KMS @ 100 ppm) (15.08 g flower^{-1}).

The highest fresh weight was recorded in T_1 treatment which was due to the least physiological change in weight of this treatment as compared to other treatments. The present findings are comparable with that of Lakshminarayana and Prashanth (2020) in gladiolus.

4.3.9 Dry weight (g.flower^{-1})

The results related to changes in dry weight during vase life period of cut gypsophila Cv. Star World treated with best treatments of experiment I and II are presented in the table 4.3.8.

From the data it is clear that, there was significant difference observed among the treatments on dry weight. Among the treatments, T_1 treatment (sucrose @ 2 % + 8HQS @ 200 ppm + KMS @ 200 ppm) recorded the highest value (9.5 g flower^{-1}) and it was comparable with T_2 treatment (8.75 g flower^{-1}), while it was lowest in T_4 treatment (sucrose @ 2 % + 8HQS @ 100 ppm + KMS @ 100 ppm) (7.55 g flower^{-1}).

The highest dry weight in T_1 treatment was due to the same treatment registered maximum fresh weight over other treatments.

4.3.10 Water uptake to water loss ratio

The data on water uptake to water loss ratio during vase life period of cut gypsophila Cv. Star World treated with best treatments of experiment I and II are presented in the table 4.3.10. and fig. 4.3.5.

Table 4.3.8. Effect of sucrose, biocides and antioxidants on fresh weight and dry weight (g flower^{-1}) of gypsophila Cv. Star World

Treatments (T)	Fresh weight (g)	Dry weight (g)
T_1 Sucrose 2 % + 8HQS 200 ppm + KMS 200 ppm	17.03 [a]	9.5 [a]
T_2 Sucrose 2 % + 8HQS 200 ppm + KMS 100 ppm	15.72 [ab]	8.75 [ab]
T_3 Sucrose 2 % + 8HQS 100 ppm + KMS 200 ppm	15.33 [ab]	7.97 [b]
T_4 Sucrose 2 % + 8HQS 100 ppm + KMS 100 ppm	15.08 [b]	7.55 [b]
S.Em	0.29	0.19
CD (p = 0.05)	0.86	0.58

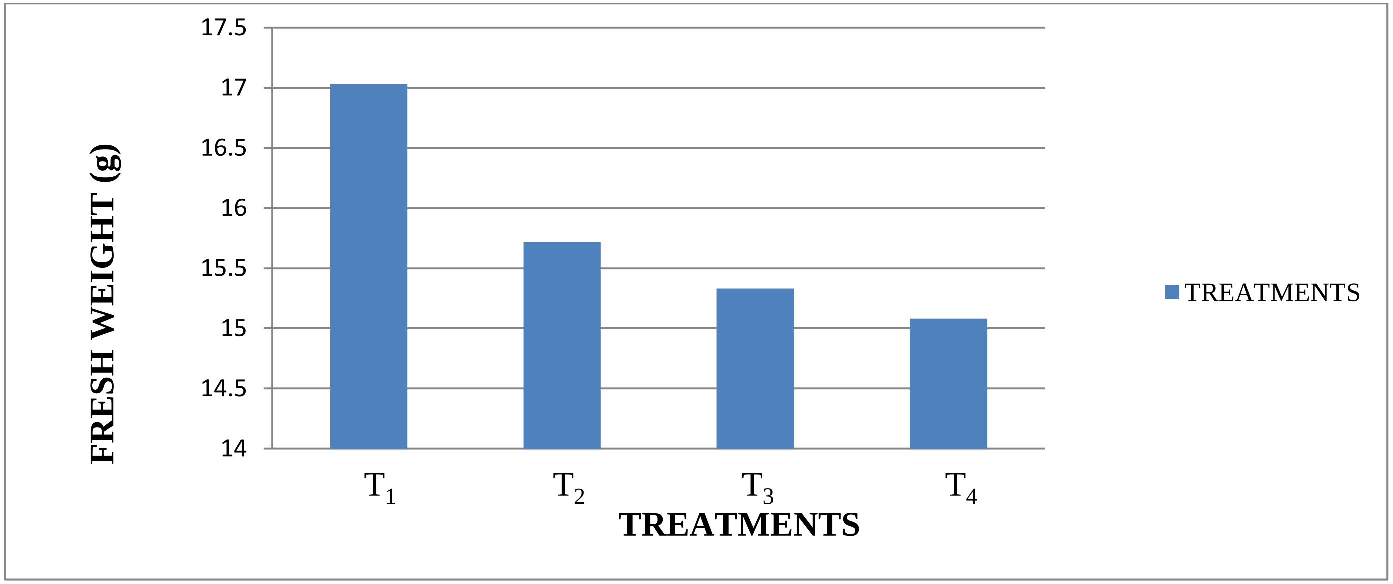

Fig. 4.3.4. Effect of sucrose, biocides and antioxidants on fresh weight (g.flower^{-1}) of gypsophila Cv. Star World

Table 4.3.9. Effect of sucrose, biocides and antioxidants on water uptake to water loss ratio of gypsophila Cv. Star World

Treatments (T)	**water uptake to water loss ratio**									
	Days									
	1	**3**	**5**	**7**	**9**	**11**	**13**	**15**	**17**	**mean**
T_1 Sucrose 2 % + 8HQS 200 ppm + KMS 200 ppm	0.987	0.975	0.953	1.01	1	1.02	0.983	0.890	1	0.980 [a]
T_2 Sucrose 2 % + 8HQS 200 ppm + KMS 100 ppm	0.966	0.969	0.990	1.04	0.973	0.929	0.942	0.985	1.1	0.870 [b]
T_3 Sucrose 2 % + 8HQS 100 ppm + KMS 200 ppm	1.01	1.029	0.951	0.948	0.923	0.972	0.947	0.901	0.901	0.953 [a]
T_4 Sucrose 2 % + 8HQS 100 ppm + KMS 100 ppm	0.977	0.934	0.883	0.782	0.817	0.852	0.861	0.883	1	0.780 [c]
S.Em	0.018									
CD (p = 0.05)	0.051									

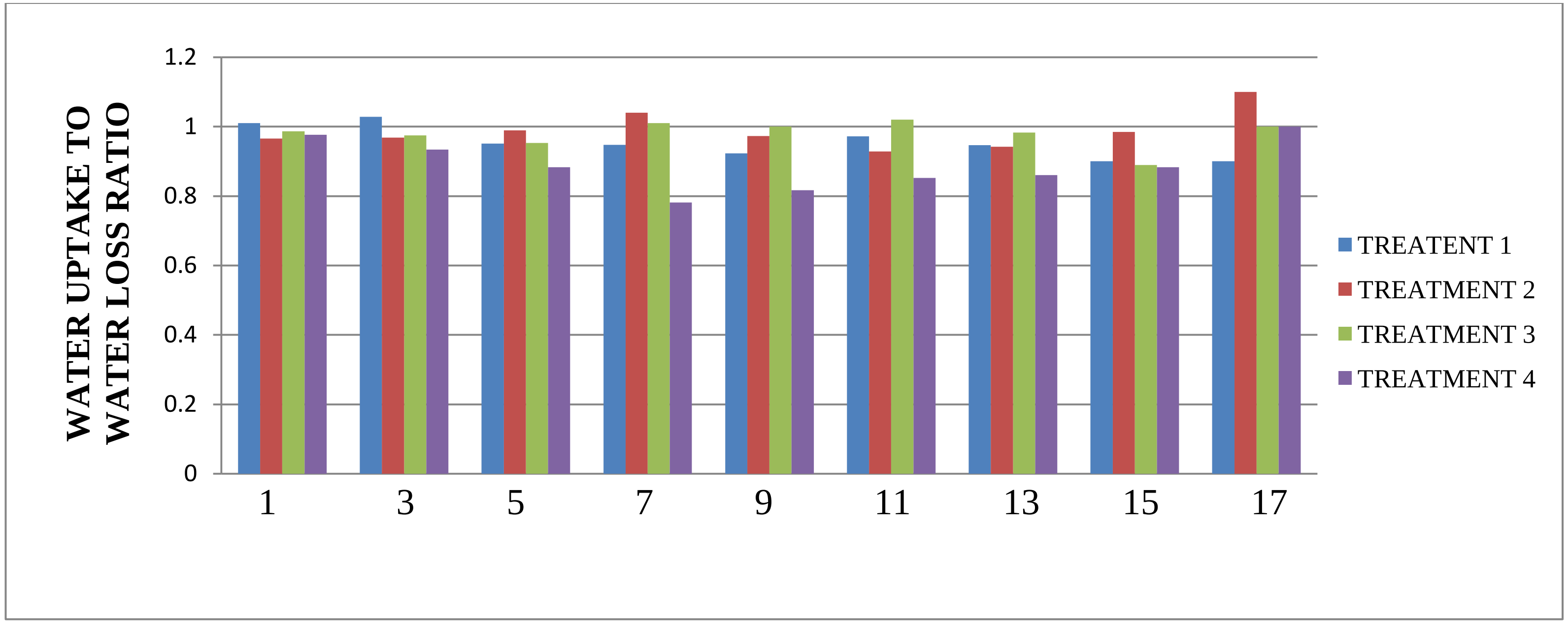

Fig. 4.3.5. Effect of sucrose, biocides and antioxidants on water uptake to water loss ratio of gypsophila Cv. Star World

Significant difference was observed among the treatments on this parameter. Maximum value was recorded in T_1 treatment (sucrose @ 2 % + 8HQS @ 200 ppm + KMS @ 200 ppm) (0.980) and was comparable with T_3 treatment (0.953), whereas significantly minimum in T_4 treatment (sucrose @ 2 % + 8HQS @ 100 ppm + KMS @ 100 ppm) (0.780).

Data revealed that maximum water uptake to water loss ratio was observed in T_1 treatment, which might be due to the same treatment registered the maximum vlaues of water uptake and transpirtional loss of water over other treatments.

4.4 Benefit Cost ratio on postharvest studies of gypsophila Cv. Star World under ambient conditions

The data on B:C ratio of effect of sucrose and biocides on vase life of cut gypsophila Cv. Star World under ambient conditions are presented in the table 4.4.1.

The B:C ratio of biocide treatments revealed that, most of the treatments are not economically viable based on benefit cost ratio. In experiment-I, compared to control T_2 (8-HQS @ 100 ppm) recorded the highest B:C ratio (32) followed by T_8 (sucrose @ 2 % + 8-HQS @ 100 ppm) (29.55)T_9 (sucrose @ 2 % + 8-HQS @ 200 ppm) (24.28), T_3 (8HQS @ 200 ppm) (14.5), T_1 (sucrose @ 2 %) (3.16) and were considered as economical.

The data enunciated on B:C ratio of effect of sucrose and antioxidants on postharvest vase life of gypsophila Cv. Star World under ambient conditions are represented in the table 4.4.2.

Among all the treatments, T_6 ($CaCl_2$ @ 25 ppm) recorded the highest B:C ratio (950) followed by T_7 ($CaCl_2$ @ 50 ppm) (500), T_4 (KMS @ 100 ppm) (244.4) and T_5 (KMS @ 200 ppm) (166.7) and were considered as more economical. Whereas, T_{1}, T_{8}, T_{9}, T_{10}, T_{11}, T_{12}, and T_{13} treatments gave B:C ratio above one.

The economic analysis data pertaining to effect of best treatment combinations of experiment I and II on vase life of gypsophila are presented in the table 4.4.3.

In experiment III, T_1 (sucrose @ 2 % plus 8HQS @ 200 ppm plus KMS @ 200 ppm) was shown highest B:C ratio (7.73) followed by T_3 (sucrose @ 2 % plus 8HQS @ 100 ppm plus KMS @ 200 ppm) (7.15), T_4 (sucrose @ 2 % plus 8HQS @ 100 ppm plus KMS @ 100 ppm) (6.89), T_2 (sucrose @ 2 % plus 8HQS @ 200 ppm plus KMS @ 100 ppm) (6.77) were economical. Considered as from this experiment it can be concluded that, combination of three chemicals was not economically effective in extending the vase life of cut gypsophila Cv. Star World.

However, the extension of vase life of cut flowers have direct influence on marketability. The prices of cut flowers fluctuates depending upon demand in the market, at peak time the prices may rose to 5 to 10 times. In that conditions, even the extension of vase life by even one day by using expensive chemicals will facilitate to catch up the market on peak days, where the B:C ratio changes more favorably towards expensive chemicals which extends vase life even one or two days. Hence, the statistically significant preservatives becomes economically viable when cut gypsophila has demand in the market.

In retailer point of view, it can be concluded that $CaCl_2$ @ 25 and 50 ppm were economically more important to extend the vase life of gypsophila flowers compared to others treatments as the cost of chemical is very cheap.

Table 4.4.1. B:C ratio of experiment I

TREATMENTS (T)	Vase life	Incremental benefit of vase life over control	Cost of chemical (Rs)	B:C ratio
T_1 Sucrose 2 %	11.2	2.40	0.76	3.16
T_2 8HQS 100 ppm	12	3.20	0.10	32
T_3 8HQS 200 ppm	11.7	2.90	0.20	14.5
T_4 SH 25 ppm	11	2.20	7.50	0.29
T_5 SH 50 ppm	11.8	3.00	15.00	0.20
T_6 $Ca(OCl)_2$ 25 ppm	10.7	1.90	40.00	0.05
T_7 $Ca(OCl)_2$ 50 ppm	10.8	2.00	80.00	0.03
T_8 Sucrose 2 % + 8HQS 100 ppm	14	5.20	0.176	29.55
T_9 Sucrose 2 % + 8HQS 200 ppm	15.5	6.70	0.276	24.28
T_{10} Sucrose 2 % + SH 25 ppm	12.8	4.00	8.26	0.48
T_{11} Sucrose 2 % + SH 50 ppm	13.5	4.70	15.76	0.29
T_{12} Sucrose 2 % + $Ca(OCl)_2$ 25 ppm	12.2	3.40	40.76	0.08
T_{13} Sucrose 2 % + $Ca(OCl)_2$ 50 ppm	12.5	3.70	80.76	0.05
T_{14} Control (Distilled water)	8.8	0.00	00.00	00.00

Table 4.4.2. B:C ratio of experiment II

TREATMENTS (T)	Vase life	Incremental benefit of vase life over control	Cost of chemical (Rs)	B:C ratio
T_1 Sucrose 2 %	12	2.40	0.76	3.16
T_2 Ascorbic acid 100 ppm (AA 100 ppm)	12.3	3.20	0.11	29.09
T_3 Ascorbic acid 200 ppm (AA 200 ppm)	12.5	2.90	0.22	13.18
T_4 Potassium meta bisulphate 100 ppm (KMS 100 ppm)	12.7	2.20	0.009	244.4
T_5 Potassium meta bisulphate 200 ppm (KMS 200 ppm)	13.5	3.00	0.018	166.7
T_6 Calcium chloride 25 ppm ($CaCl_2$ 25 ppm)	12.17	1.90	0.002	950
T_7 Calcium chloride 50 ppm ($CaCl_2$ 50 ppm)	12.2	2.00	0.004	500
T_8 Sucrose 2 % + AA 100 ppm	14.2	5.20	0.87	5.98
T_9 Sucrose 2 % + AA 200 ppm	16	6.70	0.98	6.84
T_{10} Sucrose 2 % + KMS 100 ppm	16.2	4.00	0.769	5.20
T_{11} Sucrose 2 % + KMS 200 ppm	16.83	4.70	0.778	6.04
T_{12} Sucrose 2 % + CaCl2 25 ppm	13.7	3.40	0.762	4.46
T_{13} Sucrose 2 % + CaCl2 50 ppm	14	3.70	0.764	4.84
T_{14} Control (Distilled water)	8.83	0.00	00.00	00.00

Table 4.4.3. B:C ratio of experiment III

TREATMENTS (T)	Vase life	Incremental benefit of vase life over control	Cost of chemical (Rs)	B:C ratio
T_1 Sucrose 2 % + 8HQS 200 ppm + KMS 200 ppm	16.98	8.15	1.054	7.73
T_2 Sucrose 2 % + 8HQS 200 ppm + KMS 100 ppm	15.9	7.07	1.045	6.77
T_3 Sucrose 2 % + 8HQS 100 ppm + KMS 200 ppm	15.65	6.82	0.954	7.15
T_4 Sucrose 2 % + 8HQS 100 ppm + KMS 100 ppm	15.35	6.52	0.945	6.89

Chapter V

SUMMARY AND CONCLUSIONS

A set of three experiments were conducted in Department of Floriculture and Landscape Architecture Laboratory, College of Horticulture, Rajendranagar, Hyderabad during the year 2019-20 on **"Effect of different floral preservatives on postharvest vase life of gypsophila (*Gypsophila paniculata* L.) Cv. Star World under ambient conditions."** Results of three experiments are briefly summarized and concluded below

5.1 Among all combinations of sucrose along with different biocides of various concentrations used, gypsophila flowers held in vase solution T_9 treatment (sucrose @ 2 % plus 8-HQS @ 200 ppm) recorded the best values for most of the parameters *i.e.*, water uptake (27.42 g $flower^{-1}$), transpirational loss of water (22.22 g $flower^{-1}$), vase life (15.5 days), relative water content (96.38 %), fresh weight (15.9 g $flower^{-1}$), dry weight (9.4 g $flower^{-1}$) and water uptake to water loss ratio (1.276) and lowest optical density of vase solution (0.045 nm) and physiological change in weight (0.82 %), except water balance which is highest for T_8 treatment (sucrose @ 2 % plus 8-HQS @ 100 ppm) (5.24 g $flower^{-1}$) and was comparable with T_9 treatment (sucrose @ 2 % plus 8-HQS @ 200 ppm) (5.2 g $flower^{-1}$)

5.2 In studies on effect of sucrose and antioxidants on postharvest vase life of gypsophila Cv. Star World under ambient conditions, T_{11} treatment (sucrose @ 2 % plus KMS @ 200 ppm) has shown maximum for most of the parameters *i.e.*, water uptake (31.42 g $flower^{-1}$), transpirational loss of water (35.02 g $flower^{-1}$), vase life (16.83 days), relative water content (103.14 %), fresh weight (16.8 g $flower^{-1}$), dry weight (8.7 g $flower^{-1}$) and water uptake to water loss ratio (1.045) lowest optical density of vase solution (0.044 nm) and physiological change in weight (0.82 %) as compared to other treatments, whereas maximum water balance (0.66 g flower^{-1}) was observed in T_1 treatment (sucrose @ 2 %) and was statistically on par with T_{11} treatment (sucrose @ 2 % plus KMS @ 200 ppm) (-3.60 g flower^{-1}).

5.3 Among first two best treatment combinations of experiment I and experiment II, the gypsophila flowers treated with T_1 treatment (sucrose @ 2 % + 8HQS @ 200 ppm + KMS @ 200 ppm) registered maximum water uptake (27.76 g flower^{-1}), transpirational loss of water (28.90 g flower^{-1}), vase life (16.98 days), fresh weight (17.03 g flower^{-1}), dry weight (9.5 g flower^{-1}) and water uptake to water loss ratio (10.95) and lowest optical density of vase solution (0.077 nm) and physiological change in weight (2.60 %) however, there was no statistical difference observed among the treatments on relative water content and water balance parameters.

5.4 CONCLUSIONS

- The results of the experimental studies of experiment I revealed that when gypsophila flowers supplied with sucrose 2 per cent plus 8-HQS @ 200 ppm recorded maximum vase life (15.5 days) over other treatments.
- In experiment II, the gypsophila flowers treated with 2 per cent sucrose plus KMS @ 200 ppm was recorded longer vase life (16.83 days) than other treatments.
- Among different combinations of best treatment of above experiments, the combination of first best treatment of biocide and antioxidant *viz*., sucrose @ 2 % plus 8HQS @ 200 ppm plus KMS @ 200 ppm recorded maximum vase life (16.98 days) over other treatments.

FUTURE LINE OF WORK

- Further research need to be done in cold storage conditions.
- Exploring different types of packaging material for long distance transportation.

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APPENDIX - I

MONTHLY METEOROLOGICAL DATA RECORDED AT ARI, RAJENDRANAGAR DURING 2019								
Months	Temperature °C		Relative humidity (%)		Rain fall (mm)	Sun shine (Hrs.)	Wind speed (km/ hr)	Evaporation (nm)
	Max.	Min.	FN	AN				
DEC	27.8	15.8	92	51.97	0.3	6.4	0.0	2.6
MONTHLY METEOROLOGICAL DATA RECORDED AT ARI, RAJENDRANAGAR DURING 2020								
JAN	29.3	16.1	88	49	0.3	7.6	0.5	3.4
FEB	31.4	15.6	86	41	0.2	8.5	4.6	4.4
JUNE	33.5	23.3	88	59	4.8	5.8	7.8	5.2