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OPTIMIZING GROWTH AND FLOWERING IN GERBERA: PACKAGE AND PRACTICES

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ABSTRACT

Gerbera (*Gerbera jamesonii*) is a popular ornamental plant in the Asteraceae family, named after Gerber, a German naturalist. The plants are stemless, tender, and perennial herbs. They are dwarf, 30-45 cm tall & hairy. Leaves are leathery, narrower at the base and wider at the top, and arranged in a rosette at the base. They are of various colors, including yellow, orange, cream, white, pink, red, scarlet, salmon, maroon, terracotta, and various other intermediate shades. It is considered the world's fifth most used cut flower (after rose, carnation, chrysanthemum, and tulip). It has excellent ornamental value due to the typical capitulum inflorescence that displays various colors and the floral stem, which consumers highly value as individual vase decorations and bouquet compositions. Gerbera is a beautiful, commercially cut flower crop marketed in considerable quantities in the international florists' trade. These plants are grown worldwide in a wide range of climatic conditions. The most critical production areas are the Netherlands, Italy, Germany, France, and California. The Netherlands produces 420 million gerbera stems annually, valued at 145 million Dutch guilders. In Uttrakhand, Gerbera production is the highest among the other cultivated flowers, such as carnation, gladiolus, marigold, rose, and tuberose. Gerbera contributes with a production of 17,840 MT and stands as India's fourth-most crucial cut flower. The total area of gerbera in India is 820 ha, with a cut flower production of 17,840 MT and a loose flower production of 3,960 MT. However, the maximum output of gerbera comes from Uttarakhand (7,200 MT), while the maximum area coverage is from Assam (600 ha).

Keywords **:** Gerbera, Cultivars, environmental factors, cultural practices, harvesting and post-harvest management.

Introduction

Gerbera (*Gerbera jamesonii* L.) belongs to the family Asteraceae, a popular cut flower grown throughout the world in a wide range of climatic conditions. It is popularly known as 'Barberton daisy' or 'Transvaal daisy'. Genus ‘Gerbera’ L. consists of 30 species, which are of Asiatic and South African origin. Among the different species, *Gerbera jamesonii* is the only species under cultivation. Modern gerbera arose from *Gerbera jamesonii* hybridized with *Gerbera viridifolia* and possibly other species (Leffring, 1973). There is a wide range of variation available in this flower. On an average, the annual flower is 20-35 flower stick per plant and it directly related to the cultivar (Li Zhang *et al*., 2008, Singh and Mandhar, 2004). The first scientific description of a Gerbera was made by J.D. Hooker in Curtis's Botanical Magazine in 1889 when he described *Gerbera jamesonii*, a South African species also known as Transvaal daisy or Barberton daisy. Gerbera is also commonly known as the African daisy. The genus ‘Gerbera’ was named in honour of a German naturalist Traugott Gerber, who traveled in Russia in 1743. The genus consists of about forty species (Das and Singh, 1989). The place of origin of gerbera is Africa, Asia and tropical regions of

South America (Ajinkya *et al.*, 2018). Gerbera is the fifth most commercially used cut flower in the world (after rose, carnation, chrysanthemum, and tulip). It is also used as a model organism in studying flower formation. Gerbera contains naturally occurring coumarin derivatives. The Egyptians believed that they symbolized a closeness to nature and a devotion to the sun, whereas the Celts thought they lessened the sorrows and stresses of everyday life. Generally, gerberas symbolise innocence, purity, cheerfulness and loyal love. Plants are stemless, tender perennial herbs; leaves with arranged in a rosette at the base. It bears a large capitulum with prominent, yellow, orange, white, pink, or various red-colored ray florets.

Flowers have been regarded as the icon of beauty and food for our sight. Flower boosts the visual sense of human beings and meets the requirement of heart feelings. Flowers have not only aesthetic purposes also have public, financial significance. Floriculture is an important profitable enterprise and a multibillion-dollar industry that plays a role to contribute GDP in the agriculture sector. Flower demand is increasing day by day and simultaneously the land under flower cultivation and the total yield of flower is also increasing to reach about 1200 core and day by day the flower market is boosted up return (Rakibuzzaman *et al*., 2018). Gerbera is famous to the farmers for its significant economic importance. Gerbera is an important cut flower for its multiple colours, size and longevity in the vase, and it is among the first ten cut flowers in the world, ranking fifth in the global flower trade. Due to the increasing demand of flower, flower farming is rapidly flourishing in Bangladesh as well. The blooms are attractive, suitable for any type of floral arrangements and are available in different shades and hues. Besides floral arrangements, gerbera is widely used in bouquets and in dry flower crafts (Nair *et al*., 2003). The production of Gerbera was approximately US$ 220 million in 2001 representing 70 million stems sold in US alone (Broek *et al*., 2004). Horticultural and floriculture greenhouse production has increased 92.4% during the last10 years (Tzouramani *et al*., 1995). Among different flowers, contribution of market share of gerbera flower is only 0.64 percent and the retail revenue was 0.6 million USD (USAID, 2014). There are a lot of options why this kind of popular flower market share and production place is still far away from national demand. Our farmers have to collect seedling from foreign country, our breeders and breeders are still in conducting research, having no implementation to farmer's field. Now a days, our public demand is increasing towards gerbera flowers because gerbera flowers have lots of colors like violet, pink, white, and various bicolor and presented dual and semi-double blooming with shelf life. Flower color is an important breeding objective in gerbera and many varieties have been bred to obtain desirable color types (Singh *et al*., 2011).

Botanical Description

Gerbera is a perennial herbaceous plant e stalk along which the roots grow and the leaves gather on it in the form of a rosette, the leaves are fully embellished or feathered. Capitulum, a flat cluster of small florets, inflorescences are carried on a long stem called a Scape (Tjia *et al*., 2008). Gerbera blooms comprise three types of florets: The center (disc, eye) contains disc florets; around the center is a ring of intermediate trans florets; and the petals that compose the outer ring are known as ray florets. Gerbera species are tufted, caulescent, perennial herbs, often with woolly crown, up to 80 cm high. Leaves are all in rosette, elliptical with entire or toothed margin or lobed, petiolate or with a petaloid base, pinnately veined, often leathery and felted beneath. Single to several flowering stems from each rosette bear bracteate or ebracteate, simple, one-headed inflorescence-capitulum. Capitula are radiate, with several rows of bracts. Ray florets are female, 2-lipped, the outer lip is large and strap-shaped, inner lip consists of two small, thread-like lobes of white, pink or red, rarely yellow colour. Disc florets are fertile, five-lobed and irregularly 2-lipped with curled petals.

Although it is usually had as an annual or seasonal plant, the gerbera really is perennial, capable of living for several years. But in cultivation, either because frosts are registered in winter, or because the quality of the flowers is decreasing, it is usually replaced every 1-2 years.

Classification

Classification of flower is a technique for grouping of flower bloom using specific features such as arrangement of florets. Flower blooms were classified according to their blooming pattern is generally done for the visual differentiation of flowers (Taufique, 2016) Classification of flower according to their bloom can help to the commercial grower to isolate for a better way of marketing.

Gerbera daisies can be classified depending on the forms of the flower. Mainly, there are five standard types of gerbera flowers (Mehraj *et al*., 2016)

- **Single Gerberas:** Single gerberas are perhaps the most common type of gerbera flower. They flaunt a simple façade with green central disk florets that

are surrounded by a row of non-overlapping ray florets.

- **Double Gerberas:** Double gerberas, which are also called duplex gerbera daisies, have two rows of overlapping small and large ray florets or petals. The central disk florets usually come in green, black, ordark red. The 'Terracotta' variety is one famous example of double-type gerbera daisy flowers. It has double yellow petals with a hint of peach surrounding its dark red eye.
- **Crested Double Gerberas:** This type of gerbera flower falls under the double category. It flaunts a double row of overlapping petals, but with an extra inner row or two of smaller petals that can either be of a similar or different color as the outer petals. The central disk typically comes in green, red, or black. One example of a crested double gerbera daisy is the 'Winter Queen' variety. It has white petals with a black central disk or eye.
- **Full Crested Double Gerberas:** Full crested double gerbera daisy flowers display two rows of outer petals and two rows of inner petals. The first row of inner petals comprises smaller ray florets that surround and often cover the disk at the center. Because of this, the disk, which can either be red, green, or black, is either hidden or partially hidden. The 'Giant Spinner' is one of the many fascinating full crested double gerbera flowers.
- **Quilled crested doubles (Spider**): Gerbera flowers that posed overlapping rows of spike-shaped petals, with one or more inner rows of shorter petals, and a green or dark center. Floral color plays a crucial role in plant life such as plant-pollinator interactions and modifying the abiotic environment of reproductive structures. In the current study, 123 gerbera accessions were divided into six color groups (white, yellow, orange, pink, red, and purple), based on Royal Horticultural Society Color Chart calibration and colorimeter measurement.

Special types of Gerbera

Though gerbera has a numerous number of hybrids, but findings the classification from this will also helpful for future gerbera breeder for the development of hybrid. Performance of each gerbera cultivars varies with the region, season and other growing condition (Hossain *et al.*, 2015). There are about 38 different species. However, only one is popular, some of popular varieties are-

Gerbera x hybrid- It has a height of 50-55 centimeters, and presents flowers of very diverse colors: orange, red, pink, yellow, white.

(Image - Flickr / jacinta lluch Valero)

Gerbera aurantiaca- It is a species native to Africa, specifically from the KwaZulu-Natal region. It grows up to 40 centimeters, and the color of its flowers is almost always red, although it can range from yellow to scarlet. It is in danger of extinction.

(**Image - Wikimedia / Aftabbanoori)**

Gerbera jamesonii- It is a well-known variety native to South Africa. Reaches a height of about 40 centimeters**.** Its flowers are red or orange.

(**Image - Wikimedia / Adeep309**)

Gerbera viridifolia- *Gerbera viridifolia* It is found towards East Africa, in the mountainous regions, and reaches 45 centimeters in height. It produces white or lilac flowers.

(Image - Wikimedia / SAplants)

Cultivars

The genus Gerbera consists of about 45 species, of which 7 have been recorded in India. Among the species only *Gerbera jamesonii* is under commercial cultivation. Most cultivars are diploid hybrids of *Gerbera jamesonii*. Sometetraploid with increased plant and flower size have been produced from diploids. Now-a-days numerous cultivars of gerbera have been developed through hybridization.

Few important cultivars of gerbera are Cream Clementine, Maron Clementine, Delphi, Vesta, Uranus, Terraqueen, Dusty, Valentine, Diablo, Mariso and Pascal. Based on the flower heads, they may be grouped into single, semi-double and double cultivars (Loeser, 1986).

A new gerbera variety 'Claret' was released by the National Horticultural Research Institute (NHRI) in 2006. A cross was made between 'Rako' with pink and semi-double and 'Sessile' with orange and single. It produces a large yield with continuous supply of flowers and has adequate peduncle height and brilliant color**.** Another new gerbera variety 'Yellow Wing'was released by the National Horticultural Research Institute (NHRI) in 2007. A cross was made between 'Gold Finger' with yellow and single and 'Yellow Springs' with yellow and spider. It was selected specially for the use of cut-flower. 'Yellow Wing'is a vigorous cultivar with yellow (RHS YO14B), green center and spider type. The flower diameter is 10.6 cm. And inner ray floret and disc diameter is 2.83 cm and 2.03 cm, respectively. It produces a large yield with continuous supply of flowers and has adequate peduncle height and brilliant color, Gerbera species number 24 accepted species, in addition to which there are numerous cultivars and many well-established series. For this reason we present several Gerbera series and identify a few recommended varieties in each.

G. *'Everlast'*

- This variety features semi-compact plants that rise to about 35cm.
- This series was developed for pot- and container-growing and its varieties are well suited to be treated as houseplants.
- They bear single flowers that have an especially long vase life, hence the series's name.
- They also boast an especially long blooming season from early spring to late autumn.

(*Gerbera*. (n.d.-b). Kew Royal Botanic Gardens. Retrieved March 16, 2023, from https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:331624-2)

G. jamesonii *'Festival'*

This was developed by Odense's Daehnfeldt Seed and commercialised by Japan's Sakata. This series's plants produce semi-double flowers. They flower profusely from spring to early autumn but only for one season. On the other hand they are also floriferous and the blooms are on the large side. Many members have a contrasty black or chocolate eye. These compact plants reach heights of only 25-35cm and are especially suited for containers and as they are very tender.

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G. *'Garden Jewels'*

A relatively new series of fully double flowers developed in the United States and offers the hardiest varieties. With a hardiness rating of H5 this is the Gerbera that can be planted outdoors virtually anywhere in the UK. Plants of this series are floriferous, holding several flowers simultaneously, and bloom from spring to autumn. They reach heights

of 30-35cm. **Red'** has a yellow eye and pure, deep red petals. **'Fuchsia'** is effectively a bi-colour as off a small dark centre is a ring of intense electric yellow with the rays an equally intense electric pink.


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G. *'Garvinea'*

- One of the well-established series and is among the most widely available in the United Kingdom.

  Plants in this series are very tall, rising to 40-45cm.
- Plants produce semi-double flowers which are among the smaller ones at 5-6 centimetres while the plants are among the most disease-free.
- With a hardiness rating of H3 they used to be hardier than other series and other varieties but now have been superseded by genuinely hardy ones.
- They are valued for their prolonged blooming season; they flower prolifically from early spring until the end of autumn and even beyond.

'Sylvana' has a yellow disk and pure white rays.

'Orangina' has a yellow-orange eye from which radiate rays of a similar or even the same rich yellow-orange hue.

'Fleurie' has an orange-red disk and rays of an exciting deep red to crimson shade.

G. *'Garvinea Sweet'*

May be considered the 'improved' iteration of the 'Garvinea' Series. It is similar to the Garvinea series but with a couple of small but significant differences. For Gerberas, this series's plants are very hardy with some cultivars hardy to H4, and the flowers are usually a little bigger (than 'Garvinea') at 7-8cm across.**'**

'Sweet Memories' is technically a bi-colour–it has a greenish-yellow eye and while the main layers of rays are soft pink, the smaller inner rays are white producing the effect of a white ring.

'Sweet Glow' has a greenish-yellow eye and petals of a solid, intense orange-vermilion colour.

'Sweet Dreams' has disks of yellow turning orange and rays of a saturated neon'ish pink.

(*Gerbera*. (n.d.-b). Kew Royal Botanic Gardens.

Retrieved March 16, 2023, from https://powo.science.kew.org/taxon/urn:lsid:ipni.org:names:331624-2)

G. *'Jaguar*

Was specially developed for two features: early blooming and uniformity (that is in bloom size and blooming period across the colours). In the right conditions, these plants will start blooming from early spring and continue into autumn. At 25-30cm tall, they are mid-height varieties suitable for growing in the garden as well as in containers. They have comparatively a proportionally smaller spread at only about 18cm.

(*Gerbera*. (n.d.-b). Kew Royal Botanic Gardens.

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G. *'Landscape'*

Developed to be grown by home gardeners in large containers specifically for the purpose of getting florist-grade cut flowers from your patio that will last for up to two weeks in a vase.

This series's plants are propagated only via tissue culture. Plants are quite tall, reaching heights of about 45 centimetres. For the named cultivars (i.e. not the 'Glorious' sub-range) the blooming season is comparatively short, running from only July to October. The flip side is that they bear even 10 flowers simultaneously, and they are stunners, being full doubles that are 12 centimetres across. They are among the most tender of Gerberas, good only to Zone H2.

'Yellowstone' has a dark eye and rays of light but bright yellow with the smaller, inner rays providing an amber-golden accent.

'Redwood' has a dark eye and very saturated deep orange rays with all of them just tipped with yellow. **'Everglades'** – a bi-colour, has the smaller, inner rays in an intense magenta pink hue and the larger, outer ones in soft, pastel pink

(*Gerbera*. (n.d.-b). Kew Royal Botanic Gardens.

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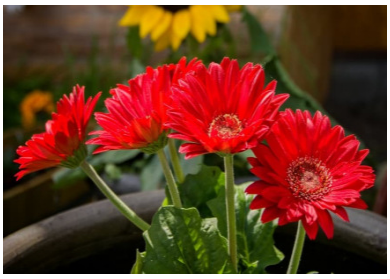
G. *'Mega Revolution'*

Revolution's big brother and this series is also meant for pot growing. Its plants have the same characteristics as those of 'Revolution' with a few differences. They are a little taller at 15-25cm and correspondingly wider, though they are not considered large plants for Gerberas. It is their semi-double blooms at 12cm that are truly huge, and range from 12-15cm.

'White with Light Eye' has a greenish-yellow eye and pure white rays.

'Orange with Light Eye' is a middle shade of orange yet is amazingly brilliant and saturated.

'Deep Rose with Light Eye' is a most unusual and striking colour that can be described only as fuchsia-magenta-rose-red.



(*Gerbera*. (n.d.-b). Kew Royal Botanic Gardens.

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Choice of different cultivars

There are a number of commercial hybrids in the market and depending on the market demand the hybrids should be chosen. Some popular hybrids with attractive colors having a good market value are listed here-

Color	Hybrids
Red	Red Bull, Ruby Red, Zingaro, Miracle, Yanara, Savannah, Stanza
Yellow	Supernova, Imperial, Dana-ellen, Piton
Pink	Rosalin, Salvador, Pink Elegance, Essence, Prime-rose, Intense
Orange	Dune, Sunset, Sun way, Golianth
White	Flake, Balance, Sylvester, Vital, Shimmer, Dalma, Artist, White house
Peach	Aida, Fosk

Environmental factors that influence growth and quality of gerbera

Environmental factors that affect plant growth include light, temperature, humidity. It's important to understand how these factors affect plant growth and development. With a basic understanding of these factors, you may be able to manipulate plants to meet your needs, whether for increased leaf or flower production.

1. Light

Three principal characteristics of light affect plant growth: quality, quantity and duration.

Quality

Light quality refers to the colour (wavelength) of light. Sunlight supplies the complete range of wavelengths and can be broken up by a prism into bands of red, orange, yellow, green, blue, indigo and violet. Blue and red light, which plants absorb, have the greatest effect on plant growth. Blue light is responsible primarily for vegetative (leaf) growth. Red light, when combined with blue light, encourages flowering. Plants look green to us because they reflect, rather than absorb, green light. Knowing which light source to use is important for manipulating plant growth. For example, fluorescent (cool white) light is high in the blue wavelength. It encourages leafy growth and is excellent for starting seedlings. Incandescent light is high in the red or orange range, but generally produces too much heat to be a valuable light source for plants. Fluorescent grow-lights attempt to imitate sunlight with a mixture of red and blue wavelengths, but they are costly and generally no better than regular fluorescent lights.

Quantity

Light quantity refers to the intensity, or concentration, of sunlight. It varies with the seasons. The maximum amount of light is present in summer and the minimum in winter. Up to a point, the more sunlight a plant receives, the greater its capacity for producing food via photosynthesis.

Duration

Duration, or photoperiod, refers to the amount of time a plant is exposed to light. Photoperiod controls flowering of plants. Plants are classified into three categories: short-day (long-night), long-day (short-night), or day-neutral, depending on their response to the duration of light or darkness.

Effect of Light On Gerbera

Effect of light on plant life depends upon its quantity or intensity, quality or kind of light, and the number of day length or photoperiod. Bright sunshine accelerates the growth, however, in summer this flower needs diffused sun light .Insufficient light will not bloom well. Gerbera plant is a day neutral plant. Costal and tropical south region needs to protect gerbera from the afternoon heat. Plant which will take morning sun , by mid afternoon , they will wanted to take refuge in the shade.

Excess light is not a problem in itself but the excessive heat associated with the high radiant energy can cause high temperature problems. During these problem periods, shading of the greenhouse to be practiced. Shading compounds can be painted on the outside of the house or shade cloth systems can be erected inside/outside the house. During winter, lighting is provided in the form of incandescent, tungsten, halogen, and fluorescent and high intensity discharge lamps (HID) to induce flower growth during winter. However, its utility could fulfil the market demands of Gerbera.

2. Temperature

Temperature influences most plant processes, including photosynthesis, transpiration, respiration, germination and flowering. As temperature increases (up to a point), photosynthesis, transpiration and respiration increase. When combined with day length, temperature also affects the change from vegetative (leafy) to reproductive (flowering) growth.

Effect of temperature on Gerbera

Temperature is a primary factor that affects plant growth, especially cell growth and elongation, and the process of growth can be differentiated by their temperature response in many cases (Takeshi and Amane, 2009). The effect of temperature on plant growth and development differs in each species, which has a specific temperature range (minimum, maximum, and optimum) during its life cycle (Hatfield and Prueger, 2015). For instance, the optimum temperature for vegetative development is 37 C and for reproductive development is 30 C in cotton (Yuri *et al*., 2005)

Temperature is one of the main factors that affects the growth pattern of Gerbera, which shows vast variation in morphology and stress adaptation. Gerbera requires 22-25°C day temperature & 12-16°C night temperature for its better growth and flower production.10-20 °C is optimum temperature to encourage flowering. Most will stop flowering below 10 °C or above 20 °C Hence it is not possible to grow (for commercial purpose) under open field condition all over the year due to inadequate temp availability. Temp fluctuation can cause harmful effects on Gerbera flower .In India, solar radiation is abundant and the climate in the plains is rather hot and dry in summer month where as the coastal part is witnessed a hot and humid climate.

3. Relative humidity

RH is the ratio of water vapor in the air to the amount of water the air could hold at the current temperature and pressure. Warm air can hold more water vapor than cold air. Relative humidity (RH) is expressed by the following equation:

Effect of humidity on Gerbera

Relative humidity of ambient air is a critical parameter for crop production as it influences the water balance and photosynthesis process in the plants. A comprehensive review on leafy, fruiting, flowering plants and grains were conducted to determine the effects of varying humidity levels on plant growth. Requirement of humidity for gerbera flower production is 65-80%. Because of controlled humidity plant growth remains continuous, flower grows with attractive colors and after cutting, their shelf life also increases. Higher humidity increases powdery mildew and downy mildew incidence and lower humidity could cause the desiccation and decrease the flower quality.

Humidity control under Greenhouse

Passive and passive and active are popular methods of controlling temperature and humidity, as the air is already moist and simply allowing convection to move hot air up and out and cooler air in will effectively regulate temperature. In order to maintain desirable relative humidity levels in greenhouses,

efforts are made to use humidification or dehumidification. Humidification in summers can be achieved in conjunction with greenhouse cooling by employing appropriate evaporative cooling methods such as fan-pad and fogging systems. During rainy seasons the ambient relative humidity is high along with that of the greenhouse. In this situation the ventilation cannot lower the humidity of greenhouse air but when the ambient relative humidity is lower than ventilation could be practiced to reduce the greenhouse relative humidity.

There is a very good demand of gerbera from European markets particularly during winter and almost throughout the year in India. The availability of wide range of exotic varieties and their adaptability to grow on wide range of climate makes it a profitable cut flower crop for the growers. To obtain good quality flowers of international standard in open field condition throughout the year is almost impossible. This is due to the erratic environmental conditions where optimal climatic condition required for proper crop growth is not available. Flower crop production is highly dependent on environment, and it is very difficult to get favourable climatic conditions for optimum crop growth and development along with protection against major biotic and abiotic stresses as per the crop requirements under open field conditions. However, it is difficult to get exportable or even for domestic market good quality cut blooms of gerbera under open field condition. To meet the climatic requirements of gerbera, so that it performs to its optimum genetic potential, protected structure offers a suitable option to overcome these problems. Performance of gerbera cultivars varies with region, season and other growing condition (Horn *et al*., 1974). In gerbera, there is always demand for novel types with high yielding genotypes. Considering the importance present investigation was carried out to study the performance of different cultivars of gerbera under different growing conditions in eastern dry zone of Karnataka. The protected cultivation, also known as Controlled Environment Agriculture (CEA) or Modified Environment Agriculture (MEA) involves a series of techniques for modification of the natural environment around plants or crops. Although protected cultivation has an old history in India but practical application of protected cultivation in horticultural crops came into the picture only after 1990s.

Success of Gerbera under protected conditions has encouraged farmers to take up its protected cultivation extensively during the past few years in India. It is one among the top ten earners of the world cut flower trade. It ranks fourth in the international cut flower market and is a popular cut flower in Holland, Germany and USA (Choudhary and Prasad, 2000). Gerbera as a cut flower has tremendous demand in domestic and international markets. Due to globalization and increase in per capita income the demand for flowers is increasing both nationally and internationally. Though the crop can be cultivated in moderately warmer open sunny conditions, the performance of the crop is enhanced when grown in protected or semi-protected structures. The main advantage of growing the crop under cover or protected conditions is exploitation of genetic potential of the genotypes. Further the crops can also be managed successfully throughout the year. It produces very attractive flowers, which are having colours and suitable for pots and floral arrangements. Cultivation of gerbera in green house is more profitable as compared to cultivation in open fields. It extends the growing season and provides the year round production. Farming under greenhouse gave more return with least efforts even under adverse situation. It also reduces the total water requirement hence; this technology will be useful for the water scarcity area.

New exotic and hybrid cultivars require more care and management for high production of superior quality blooms. To meet the quality standards for export and domestic markets, naturally ventilated low-cost polyhouses are more preferred. Open ventilated saw-tooth polyhouse is sufficient for cultivation of gerbera flowers commercially under tropical and subtropical climatic conditions (Ahlawat *et al*., 2012; Sarmah *et al*., 2014). The height of polyhouse is preferably maintained at 3.4-4.0 m for efficient air circulation. Sufficient ventilation space is required on the top and sides. To control light intensity and solar radiation, shade net of 50% is used. If gerbera is grown under shade n*et al*one, the plants are to be protected in the monsoon by providing polythene cover on the top. The cut gerbera do not meet the exportable quality standard under shadenet cultivation as compared to polyhouse production. To maintain the health of the plants, optimum humidity inside the shade-house should be maintained between 75 to 80%. About 400 w/m² light intensity is required on the plant level. With supplementary lighting and increased day length, more side shoots, increased flower yield and early harvesting of flowers can be achieved. Increased CO, concentration in the greenhouse also improves growth and flowering in gerbera.

In regions where solar radiation is high, it is recommended the use of meshes in protected environments to guarantee that the gerbera production

is not affected by high temperatures, since these meshes provide shading to the plants and have properties that improve microclimatic conditions in this environment (AQUINO *et al*., 2007).There is also scope for adoption of Iot for regulating soil moisture, air temperature and humidity in closed environment of a polyhouse. (Maitra *et al*., 2020).

Productivity of a crop is influenced not only its heredity but also by microclimate around it. Plant growth and geographic distribution (where the plant can grow) are greatly affected by the environment. If any environmental factor is less than ideal, it limits a plant's growth and/or distribution.

For example, only plants adapted to limited amounts of water can live in deserts. Either directly or indirectly, most plant problems are caused by environmental stress. In some cases, poor environmental conditions (e.g., too little water) damage a plant directly. In other cases, environmental stress weakens a plant and makes it more susceptible to disease or insect attack.

4. Effect of carbon-dioxide on Gerbera

Plants use sunlight, carbon dioxide from the atmosphere, and water for photosynthesis to produce oxygen and carbohydrates that plants use for energy and growth. Increased photosynthesis results in more growth in some plants. The concentration of carbon-dioxide in Earth's atmosphere is currently at nearly 412 parts per million (ppm) and raising. Gerbera needs 1000-1300 ppm CO_2 (The leaves were much greener).

Carbon dioxide is a greenhouse gas that traps heat similar to the glass roof of a greenhouse. Extra carbon dioxide in the atmosphere increases the greenhouse effect, causing the planet to become warmer than it would be naturally. Effective use of this technology requires that houses be closed for long period each day. Due to increased CO_2 concentration, crop production time is shorter and longer stems, leaves and quality flowers obtained.

5. SOIL

Sandy loam soil with good organic matter is ideal for gerbera cultivation. The soil should be highly porous and well drained to have better root growth and better penetration of roots. The pH of the soil should be maintained at 5.5-6.5.

Under protected condition among all the different treatments soil media cocopeat is the most suitable soil media because this media gives more flowering and yield. (Laimuanpuii; Vm Prasad, Sarvanan S. Manoj Kumar, 2021).

Cultivation of Gerbera on Soil less medium

Soilless culture technique which is the most intensive system of production in horticulture and floricultural crops, has been used for several years in the Mediterranean countries and Europe (Maloupa *et al*., 1992; Brun *et al*., 2001). The commercial utilization of soilless culture is increasing rapidly in Turkey in recent years. At the same time, many scientific researches were conducted, especially on vegetable and ornamental production, on soilless culture (Raviv and Blom, 2001; Savvas *et al*., 2003). Maintaining optimal conditions for growth and development requires proper climate management and the use of well-balanced irrigation solutions that meet the mineral requirements of specific crops and cultivars (Zekki *et al*., 1996). Plants take up nutrients and water in ratios which fluctuate widely during the growing period (Savvas and Manos, 1999). Therefore, nutrification has a great importance for plant growth and yield in soilless culture. In soilless culture, all the essential elements are supplied to the plants by dissolving fertilizer salts in water to make up the nutrient solution. Different varieties and plant species have different nutrient requirements (Resh, 1991; Sevgican, 1999). When inappropriate nutrient elements and dosage which comprised the nutrient solutions, are used for plant nutrition, some nutritional disorders may occur. A nutritional disorder is a malfunction in the physiology of a plant resulting in abnormal growth caused by either a deficiency or excess of mineral elements (Resh, 1991). An increase in nutrient solution concentration to produce high-qualified crops may reduce growth and yield (Shwarz *et al*., 2002)

6. Cultivation

Preparation of Beds

Gerbera is normally planted on raised beds. The medium should be highly porous and well-drained to provide proper aeration to the root system. Well-decomposed organic manure, sand and coco-peat or paddy husk 2:1:1 proportion should be added to the beds. The soil should not be very compact after watering. While preparing the bed, single superphosphate @ 2.5 kg/30 m² is added for better root establishment and MgSO, at the rate of 0.5 kg/30 m² is applied to take care of magnesium deficiency. The raised bed height is kept 15 cm above the soil level. The bed width is 60 cm and the pathway between the beds is 30 cm.

In case of polyhouse, the dimensions of the bed in which the bed height (45 cm), width of bed (65 cm) and Pathways between beds (30 cm). In loamy soils, 15

% sand is added along with organic manures (10 kg/square metre) and rice husk (4 kg/square metre).

Sterilization of Growing Medium

Before starting gerbera cultivation, it is always important to sterilize the soil to eliminate soil-borne pathogen and nematodes. Sterilisation is done to reduce the infestation of Phytopthora, Fusarium, Pythium. Disinfection can be done by use of formaldehyde or Hydrogen peroxide (KF Bioplant 2018).

- Formalin or formaldehyde @1lt in 10 lt of water is sprinkled 1-2lt/m2 on the growing medium layer and covered it with plastic. After one week the plastic should be removed.
- Hydrogen peroxide@ 35 ml/litre of water (3.5% solution). 1 litre of solution is applied to 1 metre square bed. On the next day gerbera seedlings can be planted.

Planting- Gerbera can be propagated by both sexual and asexual methods.

Seed: Because fresh Gerbera daisy seeds deteriorate quickly, it is best to buy fresh seed and sow it in early spring. Seed has very limited shelf-life (one fortnight only) and rapidly loses its viability unless stored under cold temperature (-5 to 5°C). They need a temperature of 21°C to 25°C to germinate, so they are usually started indoors. Seed is usually sown in trays of a suitable peat- under based compost medium. Poke holes in the mix and put a seed in each hole. If it still has its "feather" attached, that part goes at the top and should barely rise above the soil line. If it no longer has a feather, sow the seeds with the longer, pointed end at the top. Press the seeds into the planting mix but don't cover them. Water the seed-starting mix well and cover the pot with clear plastic (or a plastic bag). Monitor the pot or flat to keep the mixture moist. Germination takes two to three weeks. As soon as they germinate, remove the plastic and place the container in a warm location with good air circulation. Keep the soil damp but not wet. The seedlings are picked at 2-4 leaf stage and are ready for transplanting in about e top. 5-6 weeks. Seed propagated plants require a longer time to produce flowers. Flower should be preferably pollinated two to three times for seed set.

Asexual methods: Most of the commercially grown cultivars are propagated through vegetative means, to maintain uniformity and genetic purity (Peper *et al*., 1971). Among the vegetative means, multiplication through divisions of clumps is the most common method used for several decades. Gerbera can also be propagated through cuttings (Schiva 1975). To provide good material for shoot production, of the the mother plants have to be grown at a temperature around 25-30°C. Propagation through tissue culture is popular for rapid and large scale multiplication. A tissue culture procedure has been proven to be commercially practical in gerbera propagation. This method enables a million fold expansion per year of a desired plant (Murashige *et al*., 1974; Aswath *et al*., 2002, 2003). Shoot tips, inflorescence buds, flower s, of heads and midribs have been employed as explants for micro-propagation on modified MS medium.

Division: Mature Gerbera daisies usually have multiple crowns, and each crown has its own stems and roots. Spring and summer are the best times to divide the daisy. Dig around its base about 6 inches out from the anticipated root ball location and lift the entire plant from the ground. Gently brush the soil from the roots to see the crowns. Snap each crown off or use a sharp knife to cut the sections apart, making sure each crown is intact and has roots and stems. Replant the crowns immediately.

Stem Cuttings: As shoots develop, they are removed from the parent plant and rooted under mist or in a polythene tent by using a peat-based compost medium. Approximately 40-50 plants can be produced in 2-3 months from a single mother plant. Young stem cuttings produce roots and shoots much easily and quickly under intermittent mist. Take 6- to 8-inch cuttings from non-flowering stems. Remove any leaves from the bottom half of the cutting. Dip the bottom of the cutting into rooting hormone and insert it into a small pot filled with moist potting mix. Firm the mix around the cutting with your fingers and mist the plant. Cover it with a clear plastic bag. Place it in bright, indirect light and mist it every day. In 10-14 days, tug gently on the cutting. Resistance indicates the cutting has rooted. Give it another week or two (without the plastic bag) to develop robust roots and transplant it to a container or the garden. They are ready for transplanting in 2 or 3 months.

***In Vitro* Propagation of Gerbera:** The most commercial cultivars are propagated through vegetative means by multiplication through divisions of clumps; however, the multiplication by this method is too slow to be commercially viable. To commercialize gerbera crop and to meet the growing demand for planting material, tissue and organ culture techniques are being used as alternative methods for propagation in many countries. Most of the work has been carried on plant regeneration by adventitious organogenesis from capitulum, shoot tip, leaf, petiole and other parts of the plant. Attention should be paid to improve the technology to achieve 100% success in all

species/cultivars to meet growing demands of the growers globally. Gerberas are highly amenable to *in vitro* studies, as various explants were found to favourably respond to different culture media with different types and concentrations of growth regulators (Kanwar and Kumar, 2008).

Irrigation

Most growing plants contain about 90 percent water. Water plays many roles in plants. It is:

- A primary component in photosynthesis and respiration.
- Responsible for turgor pressure in cells (Like air in an inflated balloon, water is responsible for the fullness and firmness of plant tissue. Turgor is needed to maintain cell shape and ensure cell growth)
- A solvent for minerals and carbohydrates moving through the plant.
- Responsible for cooling leaves as it evaporates from leaf tissue during transpiration.
- A regulator of stomatal opening and closing, thus controlling transpiration and, to some degree, photosynthesis.
- The source of pressure to move roots through the soil
- The medium in which most biochemical reactions take place

Optimal irrigation scheduling could lead to higher water use efficiency, an objective of very high importance nowadays. Adequate supply of water and nutrients results in higher water and nutrient use efficiency, better production control, and avoidance of stress situations (Raviv and Blom, 2001). Irrigation control involves determination of both timing and quantity of each watering event. Methods for irrigation scheduling are usually based on calculation of crop evapotranspiration commonly performed by means of an energy balance method (Allen *et al*., 1998; Donatelli *et al*., 2006) and estimation of the couple frequency–dose.

Avoid excessive watering to gerbera. The water requirement of Gerbera plant is approximately 70ml / Plant/ day. The relative humidity should not exceed 90%, as it will lead to deformity of flowers.In case of polyhouse condition,the concentration of pH and EC of irrigation water should be maintain upto 6.5- 7.0 and < 0.7 dS/m respectively (Maitra *et al*., 2020).

Fertilizer Application

The amount of fertilizer Gerbera daisies need depends on the quality of your soil. During the spring and summer, fertilize the plants every two weeks with a water-soluble fertilizer that is high in phosphorus and low in nitrogen. For the amount to use, follow product label instructions. Alternatively, spread compost around the plants monthly.

In this 25-75 t/ha of well decomposed FYM is required. It depends on the fertility status of soil. For the first three months after of planting, application of 20:20:20 NPK @ 1.5g/li of water every two days during the vegetative stage encourages better foliage. One flowering commences, 15:8:35 NPK @ 1.5g/li of water per day is given to get better quality blooms. Micronutrients should be given weekly or fortnightly interval as per the deficiency symptoms. Fertilizer can be applied frequently at optimum level as excess application of fertilizer may cause harm to gerbera. Soil analysis must be done at an interval of two to three months to decide nutrient schedule (KF Bioplant, 2018).

To achieve a reduction in the concentration of a nutrient solution used for fertigation of miniature gerbera grown in perlite (Bres *et al*., 2012).

Cultural Care

- Select a location that receives full sun to partial shade in the hot afternoon hours.
- Plant Gerbera daisies in soil that is rich in organic matter and slightly acidic. The crown of the plant should be about 1/2 inch above the soil line so make sure not to plant too deeply.
- Water newly planted Gerbera daisies regularly. Give established plants about 1 inch of water per week and more in hot, dry weather.
- During the winter, keep perennial gerbera daisies at a temperature between 7 to 10 degrees Celsius.
- Feed them monthly during the spring and summer with a water-soluble fertilizer.
- Harvest your Gerbera daisies when the flowers are fully opened, but the center remains tight.
- To keep Gerbera daisies blooming and showy, deadhead spent blooms.

Weeding

Weeds compete with the crops for food, water and other natural resources; hence weeds must be removed. Regular weeding should be practiced in every two weeks to keep the gerbera beds weed-free. Generally, in gerbera the following intercultural is

- Recommended as good practice.
- Removal of the older leaves.
- Hoeing and loosening the soil around for proper aeration.
- Nipping of the buds that develop within the first two months.

Repotting & Separation of Suckers

- It means transferring of plants from pots and planting them in the same or larger pot.
- In every 3-year repotting should be done in Gerbera plant to separate the suckers for better growth and quality flower production.

Pathogens and Diseases Affecting Gerbera Cultivation

Gerbera production is challenged by numerous diseases caused by insect, fungal, bacterial, nematodes, viral and phytoplasma pathogens that affect its flower quality and quantity. The major pests (whitefly, aphid, leaf miner thrips, mites), diseases (powdery mildew, collar rot, root rot, stem rot, leaf spot), nematodes (root-knot, spiral), and their symptoms, biology, spread, and management have been discussed by Reddy, 2016.

Insect-Pest incidence is the major factor responsible for yield reduction in gerberas. Gerberas have a wide variety of pests such as aphids (which transmit Cucumber mosaic virus and Leaf miner, Mites, Western flower thrips and caterpillars. The whiteflies are major potential insect pests of greenhouse gerberas (Shalini *et al*., 2019). These insect pests affect plant health by sucking of their sap as well as by transmitting many diseases from infected to healthy plants.

Nematode Problems

Nematode Problems Although a multitude of plant parasitic nematodes are found associated with gerbera elsewhere in the world (Lamberti *et al*., 1987), root knot nematodes belonging to Meloidogyne spp. are predominant in India (Nagesh and Parvath Reddy, 2001). In India, yield loss in gerbera due to Meloidogyne incognita was reported to be 31.1% (Nagesh and Parvatha Reddy, 2000). A survey was conducted in the different districts of Tamil Nadu in the year of 2013 in order to determine the most important plant parasitic nematodes species associated with gerbera. The analysis of soil and root samples collected from the rhizosphere of gerbera in each district revealed the presence of only five species of plant parasitic nematodes. These are *Meloidogyne incognita, Helicotylenchus multicinctus, Pratylenchus coffeae, Tylenchorhynchus* spp. and *Rotylenchulus reniformis*. The present investigation revealed that M. incognita is one of the serious limiting factors in commercial cultivation of gerbera under polyhouse conditions present in Tamil Nadu (Manju and Subramanian, 2015). Nematodes also transmit some diseases caused by viruses such as: Tomato bushy stunt virus and other Nepoviruses which also affect gerbera and other plants grown in polyhouse/glasshouse conditions.

Fungal Disease

Gerberas have several fungal disease problems such as: root rots (by *Pythium irregulare, Rhizoctonia solani*); crown and root rot (by *Phytophthora cryptogea, P. drechsleri*); Sclerotium rot (by *Sclerotium rolfsii*); Botrytis blight (by *Botrytis cinerea*); powdery mildews (by *Erysiphe cichoracearum, Oidium crysiphoides*); leaf spots (by *Alternaria alternate*) (Farhood and Hadian, 2012), (by *Corynespora cassiicola*) and by (*Phyllosticta gerberae, Alternaria* spp.). The downy mildews, yellow discoloration on leaf, later turning light to dark brown on gerberas are caused by *Bremia luctucae* (Wolcan *et al*., 2010), and White rust (white erumpent sori) is caused by *Albugo tragopogonis* (Vazquez *et al*., 1997). The oval, circular or irregular, brown to black lesions with concentric rings on gerbera leaves are also reported to be caused by *Alternaria* spp (Mirkova and Konstantantinova, 2003)

Pest	Management
Whitefly	Spray Dimethoate (Rogor), Endosulphon (2 ml/l water)
Aphids	Spray Dimethoate 2 ml/l of water
Leaf Miner	Spray Chloropyriphos, Diclorovous (Nuvan) (1 ml/l)
Thrips	Spray Rogor, Nuvacron (2 ml/litter)
Mites (*Steneotarsone muspallidus*)	Spray Dicofol (Kelthane), WettableSulpher (1.5 g/l)
Catterpiller	Apply Thimet (Phorete) 2 g/plant apply around the plant
Thrips	Spray imidacloprid 0.4 ml/l followed by Pongamia or Neem oil

Viral Diseases Affecting Gerbera

Like other viruses, plant viruses are acellular, submicroscopic, obligate parasite and made up of nucleoprotein (DNA or RNA). Till date only RNA viruses are reported on gerbera, which may be of two types: single or double stranded. The single stranded RNA viruses are further divided into two, positive sense and negative sense. In gerbera mostly single stranded positive sense RNA [ss(+)RNA] viruses such as: Impatiens necrotic spot virus (INSV), Tobacco mosaic virus (TMV), Tomato black ring virus (TBRV), Cucumber mosaic virus (CMV), Tobacco rattle virus (TRV) are reported but a very few report are of single stranded negative sense RNA viruses are reported and Tomato spotted wilt virus (TSWV) is one among them. Many viral diseases on gerbera are reported worldwide. Some of them are: Concentric rings and distortion of leaves caused by TSWV and Necrotic spot on leaf caused by TSWV and INSV are reported from Siberia (Stankovic *et al*., 2011) and from New Zealand (Elliott *et al*., 2009), respectively. Gerbera is also host for TMV andTBRV reported from China (Zhang *et al*., 2009). Color break on the petals, and deformed flowers on gerbera reported is due to infecting Cucumber mosaic virus on gerbera from India (Verma *et al*., 2004a), Tobacco rattle virus (TRV) are also reported on gerbera from Netherland (Schmelzer *et al*., 1966; Stouffer *et al*.,1965). In 2002, Slovenia, Chrysanthemum stem necrosis virus (CSNV) was also detected in gerbera. The identity of CSNV was confirmed by ELISA and PCR (Ravnikar *et al*., 2003).

Management of Viral Diseases

Management of viral diseases is much more difficult than that of diseases caused by other pathogens (Verma *et al*., 2002) because of the viral diseases have a complex disease cycle, efficient vector transmission and no effective virucides available. Integration of various approaches like the avoidance of sources of infection, control of vectors, cultural practices (conventional) and use of resistant host plants (non conventional) have been used for the management of diseases caused by plant viruses

By Cultural Practices- Prevention is the key for managing Tospovirus diseases because Tospovirus-

infected plants cannot be cured. If viral infection is suspected in gerbera plants, samples should be sent to testing facilities to confirm the presence of the virus. Once the disease has been identified, the only management option is to discard infected plants (Whipker, 2014). However, managing the vector of the virus, the spread of western flower thrips can be minimized. This can be done using strategies to physically exclude the pests such as installing fine mesh screens (mesh size>135nm) external openings to prevent entry of thrips vectors into the greenhouse. Monitoring using indicator plants, such as petunia, or sticky cards can be helpful to provide early warnings of the presence of F. occidentalis (Allen and Matteoni 1991).

Biological Controls - Biological controls can be effective for controlling of Thrips species when their populations are low. Some predator species have been identified for control of western flower thrips. These are: *Euseius stipulatus*, *Metaseiulus occidentalis* (Nesbitt), *Amblyseius andersoni* (Chant), *Amblyseius scutalis* (Athias-Henriot), and *Amblyseius* (Euseius) *tularensis* (Congdon) (Elizabeth *et al.,* 2016).Lady beetles (Coleoptera: Coccinellidae), ladybugs, or ladybird beetles are among the most visible and best known beneficial predatory insects. Over 450 species are found in North America. Most lady beetles in North America are beneficial as both adults and larvae, feeding primarily on aphids. They also feed on mites, small insects, and insect eggs. The biological control of aphid vectors population (capable of transmitting CMV and TAV and potyviruses in several plant species) has been attempted by ladybird (*C. transversalis*), a predator of aphids. The feeding behavior of *C. transversalis* has been observed on chrysanthemums. Differentlarval stages, as well as adult lady bird predators have been explored for minimizing aphid population. The larval stage is found to be most efficient for feeding of aphid population as compared to adults. It feeds approximately 20 aphids per minute. It was also observed that aphids quickly migrate from the ladybirds. These observations may be utilized for minimizing the aphid population, indirectly minimizing the load of the virus in nature (Kumar, 2009). It is suggested that such eco-friendly approaches of virus-disease management are needed to be developed which neither has adverse effect on human health, nor possesses hazards to the environment. Predation has immediate consequences for prey fitness and early assessment of predation risk may be advantageous for prey. Ninkovic *et al.,* 2013 investigated the ability of the bird cherry-oat aphid, *Rhopalosiphum padi*, to detect one of its important predators, seven spot ladybird, *Coccinella septempunctata*, via chemicals in the predator's walking track. This avoidance mechanism may play an important role in the biological control exerted by predatory ladybirds on aphid populations (Ninkovic *et al.,* 2013).

Use of Virus-free Gerbera Planting Material - Viruses spread from mother plant to their progenies

through infected cuttings, tubers and other vegetative plant materials that have great possibility of virus transmission. Use of virusfree planting material and their transplantation in greenhouses that isolates crop from other plants which harbor or may harbor viral diseases has been suggested for better crop production yield (Agrios, 2005).

Harvesting and Post-Harvest Management

The flowers have long vase life (8 to 12 day) and can withstand long distance transportation. Once planted, gerbera becomes a two-and-a-half-year crop where first flowering starts after three months of transplanting. The average yield under greenhouse is 200-250 flowers/m²/year and 90% first grade flowers can be obtained with proper cultural operations. Under open field condition the average yield of flower is around 120-150 flowers/m²/year with nearly 15% of the flowers will be of the first grade. Flowers are usually full-grown harvested when fully open and also when the second circle of disc florets shows pollen. At this stage the outer 2-3 rows of disc florets are perpendicular to the stalk. The heel for the stalk should be cut 2-3 cm above the base and kept in fresh chlorinated water. If harvested too early, it will fold over and collapse. Vase life of a cut flower is generally 7-8 days. For marketing, the stalk length should be 45-60 cm and flower diameter 9-12 cm.

Keeping quality is an important parameter for evaluation of cut flower quality, for both domestic and export markets. The techniques of prolonging the vase life of flowers will be a great asset to the growers and users (Nair *et al*. 2003). Keeping quality of flowers is affected by internal as well as external factors. The internal factors which are responsible for the keeping quality of cut blooms are the rate of water absorption and transpiration. Respiration is another internal factor that affects the life of the cut flower. Some environmental factors such as temperature, relative humidity and wind velocity also affect cut flower life (Meman & Dabhi 2006). Preservative solutions generally used for lengthening the vase life and improving the quality of flowers are 5% sucrose +20 g AgNO,; 2% sucrose + 150 ppm NiCl; 3% sucrose + 200 ppm 8-HQC or 2% of sucrose + 50 Ppm DICA.

After harvesting, gerbera flowers experience many problems, including the presence of bacteria in the preservative solution in the vase that causes flower curvature and stem folding (van Doorn and de Witte, 1994), and bacterial infection can be prevented by prior treatment with sodium hypochloritestems or by adding silver nitrate ($AgNO_3$) to vase water (Meetern, 1978). Hydroxyquinoline sulfate, a bacteriostatic agent, is widely used in the flower's conservation (Nowak and Rudnick, 1990).

Maintain good quality and extend the vase life of these flowers is essential for good acceptance of these products on the market (Sardoei *et al*., 2013)

Durigan & Mattiuz (2009) observed that gerberas 'Suzanne' stored at 2ºC, 4ºC and 6ºC showed vase life higher than those stored at 20ºC, being these temperatures effective in the maintenance of the appearance and decorative quality of the inflorescences.

Floralife® PRG Pretreament product has been specially formulated for use immediately after harvest, as well as after a prolonged dry transport, to encourage vase life for rose and Gerbera cultivars. The product is used as a tablet form and needs to be mixed with water to make the final solution. The treatment helps to condition the water and keep it clean, while facilitating good hydration and sanitation through the flower stems.Flower stems treated with Floralife® PRG Pretreatment solution maintained stem turgidity and reduced the "bent-neck" flowers which decrease flower vase life. (Ranwala 2010)

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Authors Contribution

Each author associated with this paper has significantly contributed in collection of reviews, compilation and preparation of manuscript. The brainstorming of each author was done by the corresponding author. The final editing and correction is done by the corresponding author.

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