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Exploring the Impact of Silver Nanoparticles on the Longevity of Cut Flowers: A Comprehensive Review

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Abstract

Silver nanoparticles (AgNPs) have recognizable biological activity and have the potential to be inventive plant growth enhancers. The application of silver nanoparticles (AgNPs) in horticulture has received special attention due to its potential to prolong the vase life of cut flowers. AgNPs validate to accelerate plant growth, leading to increased biomass in the leaves and bulbs as well as faster flowering. Plants treated with silver nanoparticles showed positive indications such as higher leaf greenness indices, longer flowering durations and maximize flowering. This review consolidates current research findings and examines the several effects of silver nanoparticles on the post-harvest longevity of cut flowers. This review will draft a valuable insight into the beneficial outputs of AgNPs to control the postharvest biology of horticultural products, particularly about prolonging the vase life of cut flowers and also current study will provide future perspective of limitations, application and challenges of silver nanoparticles in the floriculture industry. It will be a better milestone for future study of silver nanoparticles in many aspects.

Keywords: Floriculture, Cut Flowers, Vase Life, Nano Silver And Post-harvest Treatment.

Introduction

Floriculture is an age-old farming pursuit with massive potential for generating gainful self-employment among small and marginal farmers. Floriculture is a distinct branch of horticulture that includes the commercial production of cut flowers, loose flowers, bulbs, landscape plants, their marketing and the production of value-added products from them. Floriculture is achieving significance all through the world and is currently considered one of the nation's dawn industries both cut flowers as well as loose flowers. In the world Netherland, Germany, USA and Japan are the main producers of floriculture products[1].

Netherland is an important producer of cut flowers, 54% in the Global Market of Production. India is on the 18th rank contributing 0.6 % share in global floriculture trade. In recent times Karnataka, Tamil Nadu, Andhra Pradesh, West Bengal, Maharashtra, Rajasthan, Delhi and Haryana are the significant floriculture centers in India[2]. The area under flower crops in India has increased to 3,24,000 Hectares with the production of 8,23,000 million tonnes of cut flower stems and 27,85,000 million tonnes of loose flowers. Research work on floriculture is being carried out around the world by different Research institutes like the National Agriculture and Food Research Organization (Japan), Research Institute of Pomology and Floriculture (Poland), National Institute of Floricultural Science (Japan), etc. Research work on floriculture is executed in India at several research institutions under the Indian Council of Agricultural Research and Council of Scientific and Industrial Research, in the horticulture/floriculture departments of State Agricultural Universities(SAUs) and under the All India Coordinated Floriculture Improvement Project (AICFIP) with a network of about 20 centers. The All India Coordinated Research Project on Floriculture was established to carry out nation wide inter disciplinary research by linking ICAR Institutes with State Agricultural Universities (SAUs). Currently, the Coordinated Project has 21 Centres which include 15 budgetary, 4 institutional and 2 voluntary Centres. The main research institutions related to floriculture in India are the Directorate of Floricultural Research by ICAR at Pusa, Central Institute of Horticulture, National Horticulture Board, Indian Agricultural Research Institute (IARI), Central Island Agricultural Research Institute, Maharana Pratap University of Agriculture and Technology, etc. Flower production is affected by various biotic and abiotic factors. Cut flowers need proper post-harvest management operations. This is because the vase life of cut flowers is one of the most important post-harvest issues in the flower industry[3].

In Floriculture flower production is one of the strategies in many countries of the world. After the start of flower production in India, flower production became a new area of growth and transformation plant of the country. Floriculture has great social, aesthetic and economic advantages. The beauty of the flower lies in the freshness of the flowers for a longer time without losing their aesthetic value. All along the marketing channel, there is a huge loss in the value of cut flowers which could be 50 percent of the farm value[4].

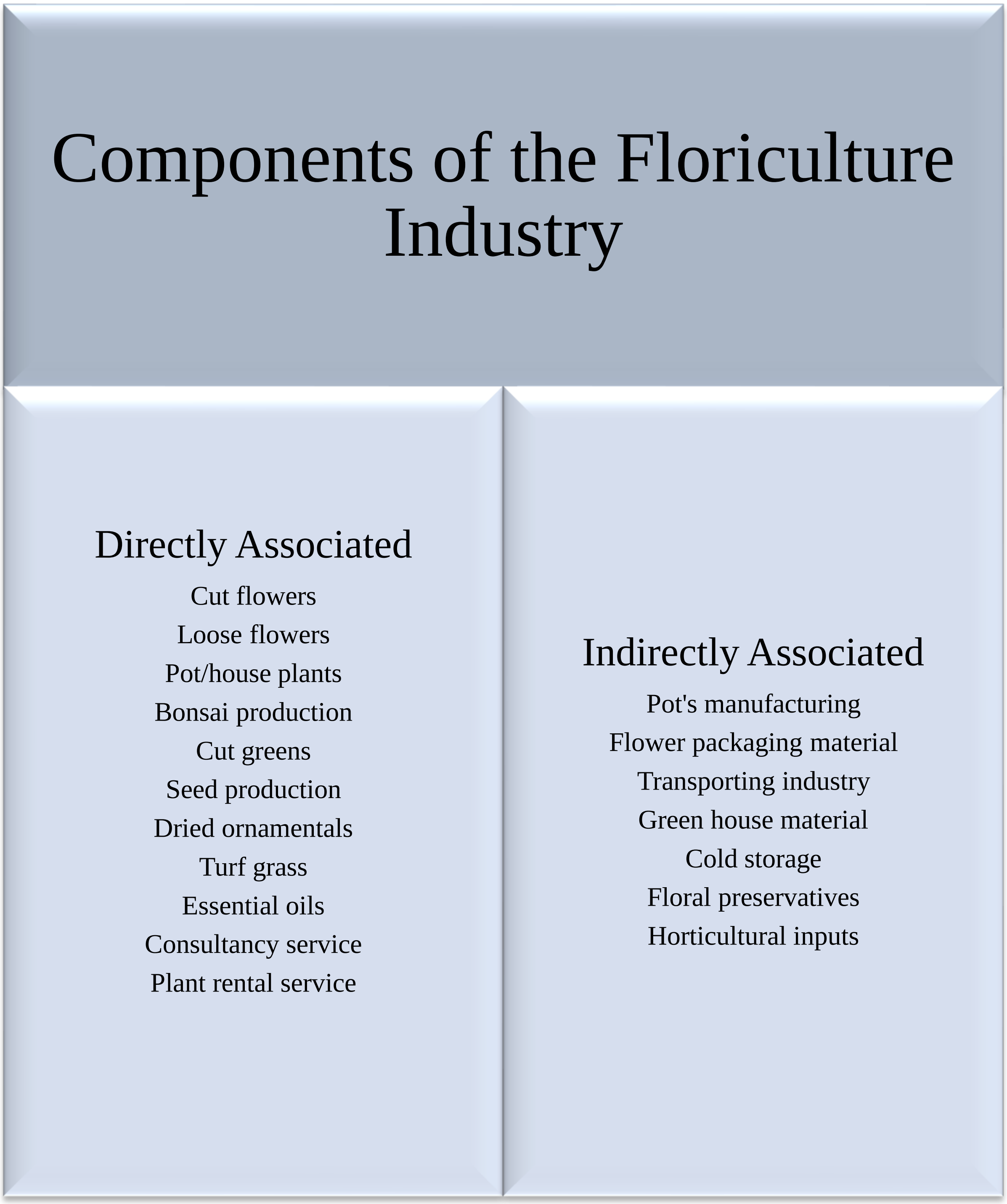

Fig. 01: Components Of The Floriculture Industry.

Hussen and Yassin (2013) stated that there are 10-30% losses in rose-cut flowers due to post-harvest damage, which is the main floriculture problem. So freshness and other quality characteristics of cut flowers require management of factors that lead to the diminished value of the products. Post-harvest life of cut flowers is affected by several factors like- plant genetics, environment, chemical factors, water stress and microorganisms that grow in vase solution. Due to such problems, different growers use different techniques to enhance the vase life of cut flowers with good quality and health of sellers and buyers. After being detached from the mother plant the cut flowers are deprived of their natural resources of water and nutrients, as a result, all life processes depend on the reserved food materials. Approximately 20-40 % of the cut flowers are lost due to improper post-harvest handling. Post-harvest losses can be reduced by techniques like temperature management during storage[5]. For both domestic and export markets assessment is a principal parameter for maintaining the quality of cut flowers. Two principal elements that play a dominant role in the postharvest physiology of cut flowers are the supply of carbohydrates and water balance in the stem. Sugars are used in respiration as an energy source, which keeps turgidity. flower freshness is mainly maintained by turgidity. Sucrose treatment leads to an increase in the mechanical rigidity of the stem, which is due to cell wall thickening and lignification of vascular tissues[6]. The main common causes of early senescence in cut flowers are inhibition of water uptake, immoderate water loss, low carbohydrates providing for respiration, ethylene production, assault via microorganisms and vascular system blockage[7].

Cut flowers are sensitive to microbial contamination in the vase solution, these microbial contaminations cause shortening of the vase life of cut flowers. Nano silver is a nano-sized elemental silver, which is considered an inorganic antibacterial substance with sturdy antibacterial activity and broad spectrum, because of its small molecule size, massive definite surface area and extraordinary physical and chemical properties[8]. Nanosilver is broadly used in the conservation field due to its many extraordinary properties and benefits like easy preparation, non-toxicity and ecological and environmental protection[9].

Many authors reported nano silver extends the vase life of many cut flowers. Nanosilver is extracted from different parts of plants by various methods. It is also prepared by many industries. There is a wider opportunity to use nanosilver. There is inadequate information regarding the use of nano Silver as an option in the vase life longevity of cut flowers in India. So this paper intends to check the impact of nanosilver on the vase life of cut flowers in India in addition to understanding and information provision for customers.

Cut Flower

Cut flowers are fresh parts of plants such as flowers inflorescences or buds. Cut flowers are used for decorative purposes, in weddings, funerals, gifts on occasions and in times of illness. When managing cut flowers, post-harvest treatments are crucial to extending the vase's life[5].

Various cut flower varieties are assessed based on how well they meet various quality standards that are taken into account by clients or consumers at every stage of the marketing process. Cut flowers are assessed depending on their water uptake, transpiration rate, water balance, increment or decline in fresh weight, vase life and anatomical qualities[6,10,11,12].

Vase Life Of Cut Flower

The vase life of cut flowers depends on post-harvest treatments and it varies among species and cultivars. The long life of cut flowers is one of the main challenges of the floriculture industry because the vase life of cut flowers is the measurement of quality. The vase life of the flower depends on many factors such as post-harvest treatments which maintain the freshness of the flower and extend its vase life until the final utilization by end users. Maintaining cut flower quality, its long life with the freshness of the flower is one of the most important problems of cut flowers. The methods employed to extend the vase life of cut flowers are crucial for producers, distributors and end consumers. A common methods to extend the vase life of cut flowers is use of preservative compounds in the vase solution. Because of this reason use of nanosilver as preservative compounds becoming popular in prolonging the vase life of cut flowers.

Nano Silver

Due to the outbreak of infectious illnesses induced by various pathogenic microorganisms and the development of anti-microbial resistance, pharmaceutical organizations and scientists are looking for new antibacterial agents. In the current situation, nanoscale materials have emerged as novel antimicrobial agents owing to their excessive surface area to volume proportion and the one of a kind chemical and physical characteristic features[8,13]. Silver nanoparticles are nano-sized elemental silver and their size is between 1 nm and 100 nm. Nanosilver is thought to release monovalent silver ions (Ag^+) which replace the hydrogen cation (H^+) of sulfhydryl or thiol groups (-SH) in bacterial cell membrane surface proteins, this causes cell death by decreasing membrane permeability[14]. Nanosilver is an unconventional antimicrobial compound that can kill approximately 650 species of bacteria in water[15,16]. The use of silver nanoparticle compounds is relatively new for cut flowers. The implementation of nanosilver treatment in a preservative solution is the panacea for cut flowers[17,18].

The silver nanoparticle has high strength, easy application and no side effects. Many tests also proved that Silver nanoparticle treatment is more productive than other antimicrobial agents so nanosilver has been used to extend the vase life of several species of cut flower.

Certain levels of nanosilver are mandatory to inhibit microbial growth in the vase solution of cut flowers. Nanosilver from different companies is smoothly available in the market, but one can also simply synthesize silver nanoparticles using plant extracts. Plant-mediated synthesis of silver nanoparticles is non-toxic, environment-friendly, cost-effective and easily scaled up.

Role Of Nano Silver In Vase Life And it's Mechanism Of Action

Shabani *et al*. (2011) examined the impact of various concentrations of silver nanoparticles on *Strelitzia reginae* and found that silver nanoparticles can drum out stem-end microorganisms and escalate solution uptake and vase life[19]. The silver nanoparticles have an extraordinarily large surface area which presents better contact with microorganisms, because of this quality nanosilver exhibits efficient antimicrobial properties in contrast to different salts. The nanoparticles penetrate inside the bacteria by getting attached to the cell membrane. The bacterial membrane has sulfur-containing proteins. In the cell, the silver nanoparticles engage with these sulfur-containing proteins as well as with the phosphorus-containing compounds like DNA. The bacterial cell is exposed to silver nanoparticles, it produces a low molecular weight area in the middle where the bacteria congregate to protect the DNA from the silver ions. The nanoparticles preferably assault the respiratory chain and cell division finally prompting cell death. Silver ions are released in the bacterial cells by nanoparticles and this silver ion enhance bactericidal activity[13,14,20,21].

NS using *Chenopodium ambrosioides L.* increased the vase life, fresh weight, water uptake and decreased bacterial count in vase solution in *Chrysanthemum cv. Puma.* Maximum vase life (21 days), highest water uptake and highest fresh weights (122.9 g) were observed at 0.01mM concentration of silver nanoparticles. When we increased the concentration of silver nanoparticles in vase solution the number of bacteria in the vases decreased. The minimum bacterial count in the vase solution was observed between 0.10 mM to 5.00 mM concentration of silver nanoparticle[22].

Tuberose (Polianthus tuberosa), maximum vase life (10.5 days), fresh weight (183.2 g) and highest water uptake (49.8 ml g^{-1}) were noticed at 45 mg L^{-1} nano-silver concentration. The was noticed at 45 mg L^{-1} nano-silver concentration[23]. In *chrysanthemum (Chrysanthemum morifolium L.)*, Treatment with the concentration of 10 mg L^{-1} nanosilver showed the maximum (17.16 days) vase life and fresh weight loss (6.87 g). The lowest stem bacteria colonies (23.33 Log10CFU mL^{-1}) were observed at 20 mg L^{-1} Silver nanoparticles concentration[24]. Silver nanoparticles increased the vase life, water balance and water uptake in *Rose cv. Movie star*. Maximum vase life (21.9 days), maximum water balance and very few microorganisms were observed when we gave treatments with 10 mg L^{-1} Nano silver + 5% sucrose solution for 24 h followed by holding the samples in 0.5 mg L^{-1} Nano silver plus 2% sucrose solution[25].

Carnation *(Dianthus caryophyllus CV. 'White Librity'),* longest vase life (26.3 days) was obtained with 5 ppm Nano silver treatment. Maximum fresh weight was observed in flowers kept in the solutions which contained 80 ppm Nano silver treatment. The lowest bacteria concentration was obtained with 5 ppm nanosilver treatment[26]. In *gladiolus*, maximum vase life (11.75 days) and maximum total water uptake (31.87ml) were observed at 4% sucrose + 4ppm nano silver treatment. Maximum fresh weight of cut spikes and relative water content was observed at 4% sucrose + 4ppm nanosilver treatment. Less bacterial colony (06 ± 02 CFU) was observed at 4% sucrose + 4ppm nanosilver treatment[27].

Peonies*(Paeonia lactiflora Pall.),* Maximum vase life (12 days) observed at 30 mg L^{-1} Nanosilver concentrations. Maximum relative water uptake and fresh weight were also observed at 30 mg L^{-1} nanosilver concentrations[28]. In *Carnation flowers 'Omea'*, The longest vase life (12 days) was obtained with 25mgL^{-1} silver nanoparticles treatment. Maximum relative fresh weight (106 %) was observed with 25mgL-1 silver nanoparticles treatment. After day 6 treatment Bacterial concentration was found zero in both 25mgL-1 and 50mgL^{-1} silver nanoparticles treated solution[29]. In *Gerbera jamesonii cv. 'Balance'*, Maximum vase life (14.22 days) was observed with 10 mg L^{-1}silver nanoparticles treatment. Minimum bacterial colonies (0.22 log10 CFU ml^{-1}) in vase solution were observed with 10 mg L^{-1}silver nanoparticles treatment. Loss in fresh weight was the least (6.957g) in 20 mg L^{-1}silver nanoparticles treatment[30].

Solgi *et al*. (2009) observed that in *Gerbera (Gerbera jamesonii cv. 'Dune*'), Maximum vase life (11.3 days) was observed with 5 mg L^{-1}silver nanoparticles treatment. Maximum relative fresh weight was observed for flowers kept in solutions containing 5 mg L^{-1}silver nanoparticles treatment[31]. Nemati *et al*. (2013) observed that in *Lilium orientalis 'Bouquet'*, Maximum vase life (11.3 days) was observed with 30 ppm silver nanoparticles concentration treatment. Highest relative fresh weight was observed at 30 ppm silver nanoparticles concentration treatment[32].

S. No.	Flower name	Concentration of nanosilver	Vase life in control (Days)	Maximum vase life in nano silver treatment (Days)	References
1.	*Gladiolus*	4 ppm	6	11.75	[27]
2.	*Peony (Paeonia lactiflora Pall.)*	30 mgl^{-1}	8	12	[28]
3.	*Carnation flowers 'Omea'*	25 mgl^{-1}	6	12	[29]
4.	*Chrysanthemum cv. puma*	0.01 mM	12	21	[22]
5.	*Gerbera jamesonii cv. 'Balance'.*	10 mgl^{-1}	10.38	14.22	[30]
6.	*Polyanthus tuberose*	45mgl^{-1}	6.7	10.5	[23]
7.	*Chrysanthemum morifolium L.*	10 mgl^{-1}	13.95	17.16	[24]
8.	*Lilium orientalis 'Bouquet'.*	30 ppm	6.5	11.3	[32]
9.	*Carnation (Dianthus caryophyllus CV. 'White Librity').*	5 ppm	9.6	26.3	[26]
10.	*Rose cv. Movie star*	10 mgl^{-1}	10.1	21.9	[25]
11.	*Gerbera (Gerbera jamesonii cv. 'Dune')*	5 mgl^{-1}	8	11.3	[18]

Table 01: Nano Silver Application At Different Concentrations On Vase Life.

Conclusion

Nano-sized silver (Ag+) particles (Nano silver) are recognized as having a stronger effect of inhibiting many bacterial strains and other microorganisms than silver in various oxidation states (Ag0, Ag+, Ag2+, Ag3+) because of their unique and high surface area to volume ratio. NS, a novel antibacterial agent, finds extensive application in the fields of medicine, textiles, water purification and related fields. The use of silver nanoparticles in vase solutions is an easy and economically viable technique for increasing the vase life of Cut flowers. Based on the results of this study, it could be concluded that silver Nanoparticles have the potential to improve the vase life of cut flowers. The results showed that silver nanoparticles with antimicrobial properties enhanced the longevity of the Cut flowers by suppressing bacterial growth on cut-stem surfaces and in xylem vessels and preventing vascular occlusion, decreasing water stress, increases fresh weight and water uptake. Therefore, it is suggested that silver nanoparticles after critical analysis of their immediate and long-term effect can be nominated as a suitable, low-cost agent to be used to escalate the survival, aesthetic, therapeutic and economic potential of cut flowers.

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