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Application of polyamine and boron improves quality of potted gerbera cv. "Kosak"

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Abstract

Polyamines and boron spray were applied on gerbera to study their effect on the quality of flowers in potted plants of gerbera cv. "Kosak". The experiment was laid out in completely randomized design with six treatments (control, 0.8 mL^{-1} boron, 2 mMol L^{-1} putrescine (Put), 2 mMol L^{-1} spermine (Spm), 0.8 mL^{-1} boron + 2 mMol L^{-1} Put and 0.8 mL^{-1} boron + 2 mMol L^{-1} Spm) replicated six times. Gerberas (ligules and leaves) cv. "Kosak" were sprayed once with 100 mL of each concentration as treatment. In all the treatments, 1 mL/100 L^{-1} of a non-ionic surfactant was added to improve wetting and spray distribution. The results indicated significant effect of Put, Spm and boron on measured traits ($P \leq 0.05$). Mean comparison showed that 2 mMol L^{-1} Spm produced the better quality potted gerberas. It was verified that polyamines and boron was effective to delay flower senescence of gerberas "Kosak". However, the combination of the two substances (0.8 mL^{-1} boron + 2 mMol L^{-1} Put and 0.8 mL^{-1} boron + 2 mMol L^{-1} Spm) had non significant effect on flower shelf life.

Key words: Ornamental, floriculture, potted plants, ethylene, bioregulators, polyamines, boron, gerbera

Introduction

Gerbera (*Gerbera jamesonii* Bolus) is one of the most important flower crops commercially grown and used both as cut flower and potted plant (Minerva and Kumar, 2013). Gerbera life is reduced by ethylene and anti-ethylene compounds can be used to reduce the senescence rate (Kalatejari *et al*., 2008; Elgimabi and Ahmed, 2009). Ethylene stimulates ripening of climacteric and some non-climacteric vegetables, synthesis of anthocyanins, degradation of chlorophyll (degreening), germination of seeds, formation of adventitious roots, abscission and senescence, flower initiation and respiratory and phenyl propanoid metabolism (Gross *et al*., 2002).

There is evidence that polyamine (PAs) and ethylene compete for the same precursor S-adenosylmethionine (SAM) (Bouchereau *et al*., 1999; Pandey *et al*., 2000). PAs (Put, Spm and Spd) are recognized as a new class of plant growth bioregulators (Dantuluri *et al*., 2008) and influence many biochemical and physiological processes such as cell division and senescence (Cohen, 1998).

Changes in the levels of PAs and ethylene were observed during senescence in plants like plum (De Dios *et al*., 2006) and *Hibiscus syriacus* (Seo *et al*., 2007), and under high stress conditions, there is metabolic competition between ethylene and PAs (Li *et al*., 2004). The content and synthesis of 1-aminocyclopropane-1-carboxylic acid (ACC) oxidase in flowers under ethylene production increase petal senescence, promoting ethylene synthesis, so-called autocatalytic ethylene (Van Altvorst and Bovy, 1995). Oxidative stress and carbohydrate depletion are major factors for shortened vase life particularly in ethylene sensitive flowers (Jeevitha *et al*., 2013; Saeed *et al*., 2013).

High temperatures during flower storage can cause a decrease in cell division and this effect may be linked to the level of endogenous PAs (Poljakoff-Mayber and Lerner, 1994). The concentration of PAs may vary depending on the plant organ, degree of ripeness and postharvest treatment (Teixeira da Silva, 2006; Kuznetsov and Shevyakova, 2007; Pang *et al*., 2007). PAs retard some symptoms of senescence but accelerate some of their symptoms. Although those results may indicate a role of PAs in the intracellular mechanism of senescence, there are no reasons to think that PAs may function as intracellular signals of senescence. It has been reported that PAs have the stimulated effects on the delay of senescence in carnation (Luo *et al*., 2003), lilies (Genk *et al*., 2009) and gerbera (Bagni and Tassoni, 2006).

It has also been reported that boric acid has chemical properties that inhibits the initial increase in ethylene production and can be a good competitor with affordable price (Ahmadnia *et al*., 2013). Recent research findings have greatly improved understanding of B uptake and transport processes (Brown and Hu, 1996) and role of boron in cell wall formation (O'Neill *et al*., 2004), cellular membrane functions (Goldbach *et al*., 2001) and anti-oxidative defense systems (Cakmak and Romheld, 1997).

Thus, chemical treatments as PAs and boron, when combined or isolated can improve the quality of flowers. This study aimed to assess the effect of putrescine (Put) and spermine (Spm) PAs separately and in combination with boron on quality of potted gerbera plant cv. "Kosak".

Materials and methods

Potted gerbera plants of cv. "Kosak" were obtained from commercial producer in the city of Gravatá, Pernambuco (8° 12' 35" "S and 35° 34' 10" W), Brazil. The experiment was conducted in Department of Vegetable Production, Unidade Acadêmica de Serra Talhada-UFRPE, Brazil. Following six treatments were imposed as aqueous solution: control, 0.8 mL^{-1} boron, 2 mMol L^{-1} Put, 2 mMol L^{-1} Spm, 0.8 mL^{-1} boron + 2 mMol L^{-1} Put and 0.8 mL^{-1} boron + 2 mMol L^{-1} Spm.

Boron (Nutrioxi-boron), Put (analytical standard-Fluka) and Spm (amorphous semi-solid, BioReagent) was applied as foliar spray. For each treatment, plants (ligules and leaves) were sprayed once with 100 mL solution. In all the treatments, 1 mL/100 L^{-1} of a non-ionic surfactant (Extravon®, Syngenta Agro S/A), to improve wetting and spray distribution, was added. The apparatus used for application was low-pressure hand sprayer.

Visual analysis: Quality of potted gerbera plant was calculated from the time when about 50% of the flowers and leaves were wilted or senescent (Larsen and Scholes, 1966). Plants were placed at 18 ºC and 85% relative humidity with continuous illumination for 24 hours, as recommended by van Meeteren (1978).

Statistical analysis: The experimental design was completely randomized and consisted of six plants under each treatment with six replicates. Analysis of variance was performed to detect differences between treatment means, which were separated by Duncan test ($P \leq 0.05$) using SAS/STAT software (2008 version).

Results and discussion

The developmental events taking place during senescence also involve physiological changes such as loss of water from the senescing tissue, leakage of ions, transport of metabolites to different tissues, and biochemical changes, such as generation of reactive oxygen species (ROS), increase in membrane fluidity and peroxidation, hydrolysis of proteins, nucleic acids, lipids and carbohydrates (Tripathi and Tuteja, 2007). Pandey *et al.* (2000) explained the positive impact of PAs on plant senescence as their ability to bind with membrane phospholipids and other anion components of membranes, which results in increased stability of the structures (.

In the present experiment, the PAs showed satisfactory results compared to the control, especially in plants that were subjected to treatment with Spm (Figs. 1, 2 and 3). The results showed values of about 15 and 16 days for ligules and leaves, respectively. The treatment with Put also showed good results, with values of about 10 days for ligules and 11 for the leaves. These results are comparable with the data reported by Iman Talaat *et al*. (2005) in delaying senescence of leaf discs of two diverse species of roses (*Rose damascena* and *R. bourboniana*). A study conducted on carnation stems conditioned in solutions of PAs confirmed their effect on the extension of vase life,

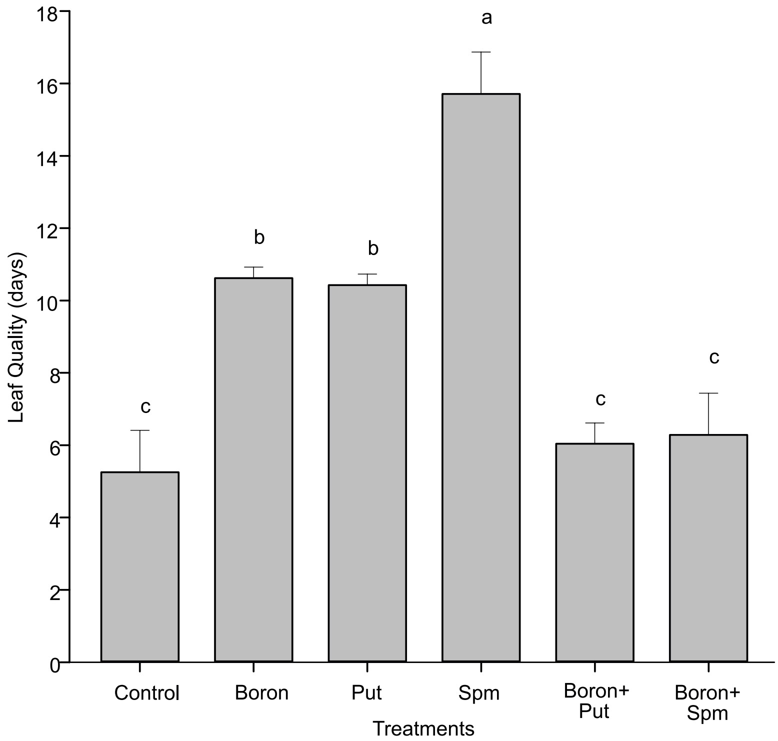

Fig. 1. Leaf quality of gerberas cv. "Kosak" measured when about 50% of the flowers wilted or senescent tissue after only one application of polyamines (Put and Spm), boron and combinantion polyamines and boron (Boron + Put and Boron + Spm).

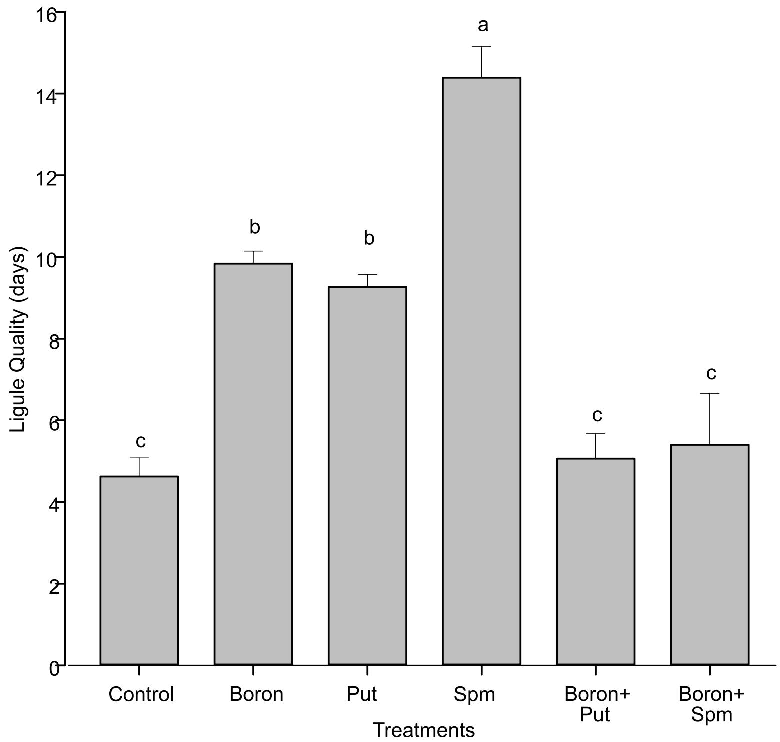

Fig. 2. Ligule quality of gerberas cv. "Kosak" measured when about 50% of the flowers wilted or senescent tissue after only one application of polyamines (Put and Spm), boron and combinantion polyamines and boron (Boron + Put and Boron + Spm).

but only when flowers were treated with PAs at the bud stage (Upfold and Van Staden, 1991). However, advancing senescence of Rosa 'Red Berlin' stems, after their cutting, resulted in reduced postharvest quality, conditioning in the solutions of PAs did not significantly prolonged the vase life (Rubinowska *et al.*, 2012).

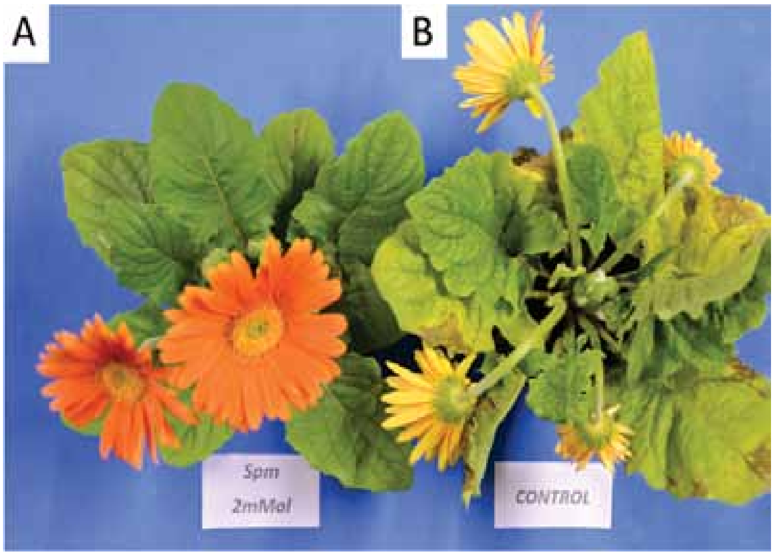

Fig. 3. Sensence in ligules and leaves after application of polyamine in potted gerbera plants of cv. "Kosak", (A): Spm and (B): Control.

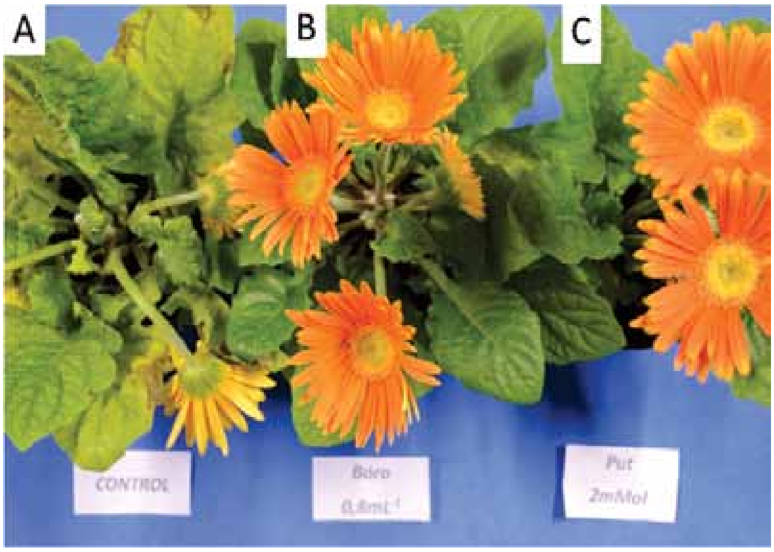

Fig. 4. Sensence in ligules and leaves after application of polyamine and boron in potted gerbera plants of cv. "Kosak", (A): Control, (B): Boron and (C): Put.

Polyamines, mainly Spm can induce synthesis of inhibitors such as difluoromethylarginine (DFMA) and methylglyoxal-bisguanylhydrazone (MGBG) promoted senescence. Jhalegar *et al*. (2012) reported that untreated kiwi fruits evolved quite a high amount of ethylene from the 3rd day onwards but PAs-treated fruits showed no evolution of ethylene until the 6th day of storage, with Spm at 1.5 mM being the most effective, followed by spermidine (Spd) at 2 mM. Exogenous application of Spd has been found to transiently delay senescence of *Dianthus caryophyllus* and *Petunia hybrida* flowers which has been implicated to be due to the ability of free Spd to bind to the main intracellular constitutive molecules such as DNA and stabilizing their structures (Gul *et al*., 2005; Tassoni *et al*., 2006).

Senescence in many plants is accelerated by the naturally occurring plant hormone ethylene (Tripathi and Tuteja, 2007). The role of ethylene in flower development has been studied to a great extent in petunia, geranium, orchids and carnation. Another probability in this study is PAs inhibit ethylene production in ligules and leaves of gerberas by regulating the activity of 1-aminocyclopropane-1-carboxylic acid (ACC) synthase and oxidase (Lee *et al*., 1997).

Reports are available that the senescence of carnation petals was inhibited by Spm, which may be due to a corresponding inhibition of ethylene synthesis. Although, addition of an inhibitor of PAs synthesis leads to elevated levels of transcripts for ACC synthase and ACC oxidase as well as to increased ethylene production (Lee *et al*. 1997).

Boron plays role in improving the quality of the ornamental and cut flowers, in particular the vase life of cut flowers (Malakouti, 2003). It is well documented that boron enhances the metabolism and translocation of carbohydrates and sugars (Malik, 2000) which provides the respiration substrate of cut flower after harvest.

In present study, mean comparison showed that 0.8 mL^{-1} boron was the most effective treatment after treatment with 2 mMol L^{-1} Spm which had nearby values 10 for ligules and 11days for leaves. Ahmad *et al*. (2010) reported the increase in vase life of cut roses by optimum boron supply which confirmed our results. In 'Karl Rosenfield' cultivar, Loyola-López *et al*. (2012) observed that the application of only water and preharvest Borocal® was enough to significantly improve the duration of vase life. The results could be due to the prevention of ethylene synthesis, by reducing ethylene production with decreasing the amount of ACC synthase, ACC oxidase activity and also can be due to inhibition of ATP utilization that is used in respiration (Ahmadnia *et al*., 2013). Furthermore, supplied with supplemental boron must have resulted an increased translocation of sugar rather than an effect on photosynthesis since the boron delay leaf senescence (Mehta, 2012). The studies of Gauch and Duggar (1953) suggests that boron binds with sugar to form a sugar borate complex which moves through cellular membranes more readily than non borated sugar molecules.

Boron being integral part of cell wall and cell membrane may have enhanced uptake of Ca (Wojcik and Wojcik, 2003) which could play a role in controlling membrane integrity and senescence regulation of plant cells (Rubinstein, 2000). However, increased application rates of boron showing leaf burn as it is readily available to plants after application and translocated to different parts where boron is involved in several vital processes and affect many pathological and physiological disorders (Conway *et al*., 1992; Fallahi *et al*., 1997; Hernandez-Munoz *et al*., 2006). The combination of PAs and boron did not show satisfactory results on quality of potted gerbera plant cv. "Kosak" as it showed discoloration of petals which may be due the degradation of amino acids and proteins. The intensity of the discoloration depends on the presence of oxidizing agents in the environment (especially molecular oxygen) and sufficient energy for the occurrence of degradation reaction (Melendez-Martinez *et al*., 2004).

In present study, Spm 2 mMol L^{-1} increased quality of potted gerbera plant cv. "Kosak". 0.8 mL^{-1} boron + 2 mMol L^{-1} Put and 0.8 mL^{-1} boron + 2 mMol L^{-1} Spm showed better quality in relation to control. It can be concluded that the Spm, Put and boron can be used for improving quality of potted gerbera plants. Since, polyamines have higher price, combination of nonionic surfactant and boron may contribute economically to the viability of potted flower industry.

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