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RESEARCH PAPER

Effects of Some Plant Growth Regulators on Quality of Potted Sunflower

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Abstract

This study was carried out to evaluate the effects of different plant growth regulators on the ornamental sunflower plant. The seedlings belonging to *Helianthus annuus* L. cv. Sunsantion F1 were planted in plastic pots (2 L) containing peat:perlite (1:1, v/v) medium at four true leaf stage. Spray treatments of aminoethoxyvinil glycine (AVG; 250 and 500 ppm), promalin (5 and 10 ppm), thidiazuron (TDZ; 5-10 μM), ethephon (100 ppm) were applied to seedlings 20 days after transfering to the pots, and treatments were repeated 10 days after the first application. Flower life (days), flower diameter (cm), stem diameter (cm) and plant height (cm) were determined. According to statistical analysis, AVG at 250 ppm significantly increased the flower life from 9.17 d in control plants to 11.08 d whereas there were no significant effects on flower diameter and plant height. Both concentrations of Promalin and TDZ increased stem diameter significantly. However, TDZ increased the flower life from 9.17 d (control plants) to 10.36 at 10 μM and 10.33 at 5 μM TDZ. Ethephon application prevented flower bud opening and caused the leaves to be yellowing. These results may suggest AVG and TDZ pre-treatments increase the quality and shelf-life of the potted sunflower plant.

1. Introduction

The sunflower (*Helianthus annuus* L.) is a member of Asteraceae family and *Helianthus* genus. The term Helianthus is derived from the Greek words 'Helios' and 'anthos', meaning sun and flower, respectively. It has consumed as medicine and food since ancient times. In the following years, with the industrial importance of sunflower oil worldwide, it became a very important oilseed plant (Naik et al., 2017). In the past 2-3 years, the problems in the food supply chain due to the COVID-19 pandemic and the Russia-Ukraine war have turned the sunflower plant into a strategic product. Today, sunflowers are also widely used as potted ornamental plants and cut flowers or garden plants for decoration purposes due to their attractive flowers in landscape areas (Elisheba and Sudhagar, 2021).

The main quality parameters for potted plants are attractive flowers, flower longevity, shape, size, and visual appearance, but each species or cultivar may have unique characteristics contributing to defining quality (Ferrante et al., 2015). Different practices can undoubtedly increase the quality of ornamental plants. However, among the various management practices adopted for manipulating growth and flowering in ornamental plants, perhaps no other management practice is as popular as using chemicals to manipulate plant growth (Sethy et al., 2016). Numerous chemicals known as Plant Growth Regulators (PGRs) are available to control plant growth in various commercial formulations (Bañón Arias et al., 2013).

Plant growth regulators can be classified into six groups including gibberellins, auxins, cytokinins, ethylene generators, growth inhibitors and growth retardants (Sajjad et al., 2017). Among gibberellins, Promalin is a common commercial PGR consisting of gibberellins A4+A7 and 6-Benzyladenine. It has long been used in many ornamental plant studies to deal with apical dominance and promote lateral bud development and branching in Algerian ivy (Al-Juboory and Williams, 1990), to reduce the incidence of leaf senescence after cold storages in potted Asiflorum lily (Funnel and Heins, 1998), to reduce disorders related with postharvest cold storage in potted *Leucospermum* (Hoffmann et al., 2015), and to increase flower development in cyclamen (Alshakhaly and Qrunfleh, 2019). Previous studies have shown that gibberellins supplemented with cytokinins work better than the use of gibberellins alone. However, the use of cytokinins or cytokinin analogues alone affects plant growth and development in different ways. Çelikel et al. (2021) reported that shoot elongation and stem enlargement of potted rose plants are regulated by TDZ applications. Additionally, TDZ spray treatments extended flower longevity in *Euphorbia fulgens* (Jiang et al., 2009), delayed leaf senescence in chrysanthemum, alstroemeria, and tulip (Ferrante et al., 2002, Ferrante et al., 2003), and increased shoot formation in nandina (Keever and Morrison, 2003).

While auxins, cytokinins, and gibberellins promote growth and development in plants, ethylene, ethylene-releasing compounds, growth inhibitors and growth retardants also play an important role in increasing the quality characteristics of ornamental plants such as plant size and compactness by suppressing growth (Marosz and Matysiak, 2005). Ethephon releases the natural plant hormone ethylene and increases its production. Ethylene release caused by Ethephon application reduces apical dominance and encourages the development of lateral shoots (Haver et al., 2002). Etephon also enables the plant to become compact by suppressing the height (Demir and Çelikel, 2018), but it is accelerated the ethylene related senescence (Wang et al., 2020). On the other hand, plants experience stress due to environmental and cultivation conditions such as temperature, poor light, low humidity, or watering during post-production period (Wagstaff et al., 2010). As a results of this stress, ethylene production is triggered, and the visual quality of the plant deteriorates (Morgan, 2011). Plants exposed to ethylene can usually no longer be sold (Olsen et al., 2015). Therefore, ethylene inhibitors are used to reduce ethylene-induced quality losses in ornamental plant. Aminoethoxyvinylglycine (AVG) is one of the ethylene inhibitors that blocks activity of ACC synthase which is a key enzyme involved in ethylene biosynthesis (Saltveit, 2005). There are much more studies on AVG treatments used for preventing ethylene production and maintaining quality parameters of fruits such as plum (Kim et al., 2021), peach (Bregoli et al., 2022), apple (Yildiz et al., 2012). There are limited studies about the use of AVG in ornamental plants such as pelargonium, ruscus, rose (Elad and Volpin, 1988) and chrysanthemum (Zheng et al., 2004).

The quality of ornamental plants is generally evaluated by flower longevity (Olsen et al., 2015) and other visual parameters which maintained by producer using PGRs. It is essential to assess the efficiency of PGRs because the effects of PGRs in plants depend on various factors such as type of PGRs, application method, application frequency, concentration, time, the plant species even cultivar, as well as the environmental conditions in which the plants were grown (Sajjad et al., 2017). Therefore, it was aimed to determine the effect of some growth regulators applied as a pre-application in sunflower (*Helianthus annuus* L.) in this study.

2. Material and Method

2.1. Plant material and cultivation

The study was conducted at a polyethylene greenhouse in the application area of the Agriculture Faculty in Ondokuz Mayıs University, Samsun, Türkiye, during the summer of 2022. The minimum, maximum, and average temperature values in the greenhouse were measured at hour intervals using a data logger throughout the growing season (Figure 1). Ornamental sunflower (*Helianthus annuus* L. cv. Sunsantion F_1) was used as plant material in the study. The seedlings were obtained from a local ornamental production company in vials at four true leaf periods. They were planted in plastic pots (2 L) containing peat: perlite (1:1 v/v) medium. The irrigation was performed with approximately 250 mL of tap water per pot daily. No fertilization and chemicals for pest and disease control were used.

2.2. PGRs treatments

Spray treatments of 250-500 ppm AVG (Retain,15% aminoethoxyvinil glycine), 5-10 ppm Promalin (1.9% Gibberellins A4+A7, 1.9% 6-Benzyladenine), 5-10 µM TDZ (Thidiazuron), 100 ppm Ethephon (2-Chloroethylphosphonic acid) and distilled water (as a control) were made before flowering time in plants. The whole plant was sprayed with PGRs (30 ml plant^{-1}) until thoroughly washed. The first chemical applications were applied to seedlings 20 days after transfer (DAT) to the pots. Then applications were repeated at 30 DAT.

2.3. Evaluated parameters

Flower longevity (the day from blooming to wilting), flower diameter (cm), stem diameter (cm)

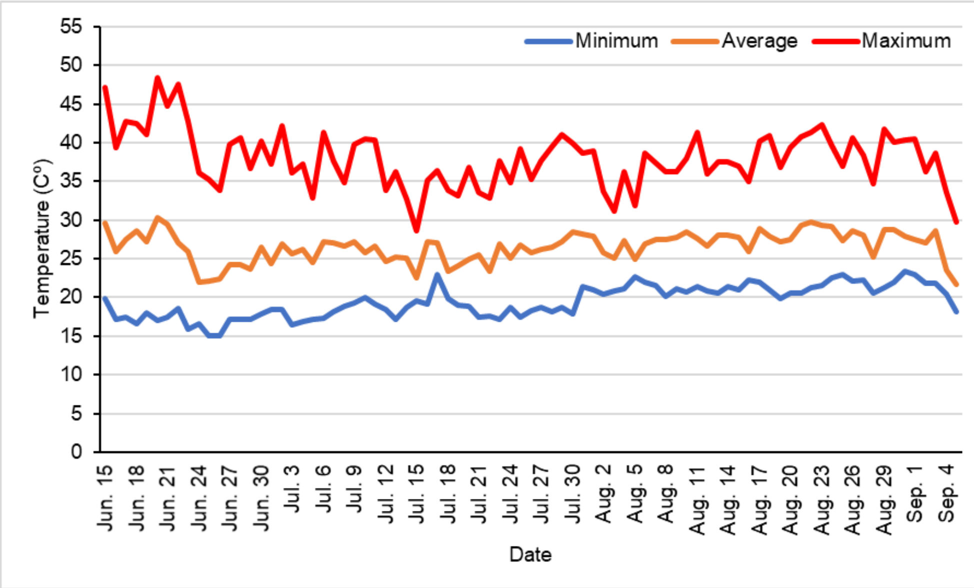

Figure 1. Temperature values in the greenhouse.

Table 1. Effects of some treatments on different quality parameters of potted sunflowers.

Treatments	Flower longevity (day)**	Flower diameter (cm)	Stem diameter (cm)*	Plant height (cm)
Control	9.17 b	10.43	8.22 b	26.43
Promalin 5 ppm	10.28 ab	9.36	9.17 a	25.37
Promalin 10 ppm	9.97 ab	9.46	9.03 a	25.95
TDZ 5 µM	10.33 ab	9.90	8.77 ab	25.23
TDZ 10 µM	10.36 ab	9.76	9.11 a	26.06
AVG 250 ppm	11.08 a	9.52	8.86 ab	24.09
AVG 500 ppm	9.11 b	10.08	8.77 ab	25.79
Ethephon 100 ppm	-	-	7.84 b	22.87

** and *, level of significance are represented by at $p<0.01$ and $p<0.05$, respectively.

and plant height (cm) were determined. Flower and stem diameters were measured with a digital caliper at full flowering and maturation stages, respectively. Plant height was measured with a ruler from the soil surface to the tip of the plant.

2.4. Experimental design and statistical analysis

The research was established according to a completely randomized design with ten replications. Four different chemicals, seven treatments, and a control group were used for applications. Each replication had a single seedling and 10 replications for each treatment were evaluated. Variance analysis was performed using SPSS statistical software version 18.0 and differences between threatments compared with Duncan multiple comparison test.

3. Results and Discussion

3.1. Effects of promalin

Effects of Promalin (GA + BA) treatments at 5 and 10 ppm on different quality parameters of sunflowers are given in Table 1. Both concentrations increased the flower life from 9.17 d (control plants) to 9.97 at 10 ppm and 10.28 at 5 ppm Promalin. There were no significant effects on flower diameter and plant height. However, both doses of Promalin increased stem diameter significantly ($p<0.05$), about 1 cm. Promalin consists of GA and cytokinin BA. It is well known that cytokinins increase stem thickness (Werner et al., 2001; Çelikel et al., 2021). Axillary bud growth was observed at 45 DAT at 5 and 10 ppm treatments of Promalin (Figure 2). Plants develop single flower heads when the ratio of auxin to cytokinin does not change. Therefore, axillary bud growth may suggest that Promalin treatments altered endogenous hormone translocation and increased cytokinin levels led to axillary bud initiation (Nagarathna et al., 2010).

3.2. Effects of TDZ (Thidiazuron)

Effects of TDZ (Thidiazuron) treatments at 5 and 10 µM on different quality parameters of sunflowers are given in Table 1. Both concentrations increased the flower life from 9.17 d (control plants) to 10.36 at 10 µM and 10.33 at 5 µM TDZ. There were no

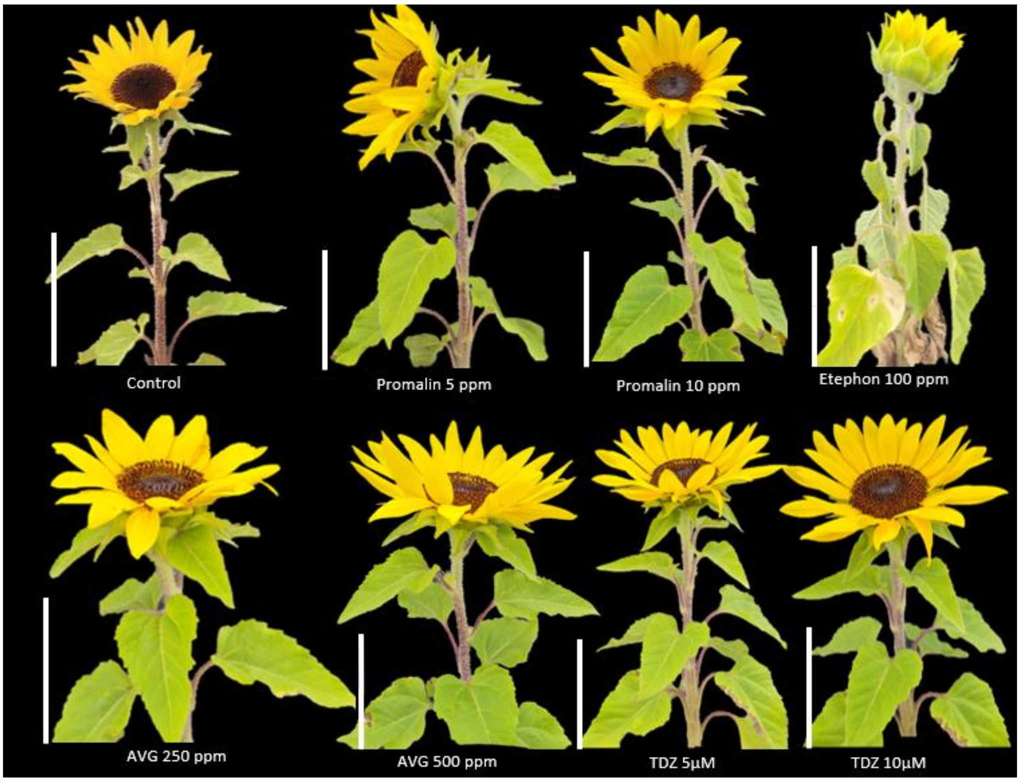

Figure 2. Effects of some treatments on visual quality of potted sunflowers 45 days after the seedlings were transferred into the pots (Scale bars: 10 cm).

significant effects on flower diameter and plant height. However, both concentrations of TDZ increased stem diameter. Thidiazuron at 10 µM significantly ($p<0.05$) increased the stem diameter about 1 cm. Thidiazuron as a cytokinin is known to increase stem diameter (Çelikel et al., 2021) and longevity (Ferrante et al., 2002; Çelikel et al., 2019).

3.3. Effects of AVG (Aminoethoxyvinil Glycine) and Ethephon

Effects of AVG treatments at 250 and 500 ppm on different quality parameters of sunflowers are given in Table 1. AVG at 250 ppm ($p<0.01$) significantly increased the flower life from 9.17 d (control plants) to 11.08 d. Sunflower from Asteraceae family is known not to be sensitive to ethylene (Reid, 1989). However, prolonged exposure of sunflowers to low concentrations of ethylene results in the abscission of ligules (Reid, 2004). In this study, ethephon (released ethylene) spray at an early stage had a negative effect on flower opening and quality (Figure 2) and it prevented flower bud opening and caused the leaves to be yellowing. Therefore, flower longevity and flower diameter were not measured. In addition, ethylene inhibitor AVG (Saltveit, 2005) at a lower concentration significantly increased the flower longevity in this experiment, while a higher concentration of 500 ppm AVG had no significant effect. Kılıç et al. (2020) reported that ethylene action inhibitor silver thiosulfate (STS) extended the vase life of sunflower cv. 'Sunrich Orange'. However, another ethylene inhibitor amino-oxyacetic acid (AOA) treatment did not lengthen the vase life of sunflowers (Mensuali-Sodi and Ferrante, 2005). Additionally, Redman et al. (2002) indicated that STS had no effect on the vase life of *Helianthus maximilianii*, while exogenous ethylene application significantly decreased vase life compared to the control group. Gast (1995) reported that the longevity of sunflower cultivars varied from 4 to 13 days. More research study with different cultivars is needed on this issue. There were no significant effects of AVG in this study on flower diameter and plant height. However, both doses of AVG slightly increased stem diameter. On the other hand, stem diameter and plant height exposed to ethephon were the lowest among treatments (Table 1).

4. Conclusion

The results of the study on the post production performance of potted sunflower may suggest that ethylene inhibitor AVG at 250 ppm as spray treatment before flowering maintains the quality and shelf life of flowers. In addition, 10 µM TDZ treatments also extend flower longevity compared to the 5 µM TDZ and control that may suggest higher concentrations of TDZ should be evaluated. Ethephon which releases the natural plant hormone ethylene negatively affected flower opening. Therefore, exposure to ethylene or stress factors which increase endogenous ethylene production should be avoided during plant growth.

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