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Research Article

Effects of benzyl adenine and monopotassium phosphate on morphological and physiological traits of potted Anthurium

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Abstract

***Anthurium andreanum* is a popular perennial ornamental plant with both potted and cut-flower cultivars, known for its colorful and attractive spathes. This study focused on the potted cultivar 'Red' and aimed to evaluate the effects of benzyl adenine (BA) and monopotassium phosphate (MKP) on growth, flowering, pigment content, and leaf mineral elements. A factorial experiment arranged in a completely randomized design with three replications was conducted, applying BA at 0, 100, and 200 mg L^{-1} and MKP at 0, 20%, and 40%. Results showed that combined application of 40% MKP and 200 mg L^{-1} BA significantly accelerated flowering, reducing days to first flower by 31% compared to control. Flower number increased by 175% under this treatment. Leaf number and length also improved, with a 107% increase in leaf number at 20% MKP combined with 100 mg L^{-1} BA. Photosynthetic pigments, including total chlorophyll and anthocyanins, were significantly enhanced. Anthocyanin content peaked with 40% MKP + 200 mg L^{-1} BA, showing a 52% increase over control. Leaf phosphorus and potassium concentrations increased by up to 24% and 43%, respectively. In conclusion, the combined application of BA and MKP led to considerable improvements in most of the evaluated traits in the potted cultivar 'Red' of *A. andreanum*, highlighting their potential for enhancing overall plant performance under commercial cultivation.**

Keywords: Anthocyanin, Chlorophyll, Flowering, Leaf nutrients, Ornamental plant, Plant growth regulator

Introduction

Anthurium andreanum, a member of the Araceae family, is an evergreen, herbaceous perennial plant widely cultivated in tropical and subtropical regions. This species is among the top ten ornamental flowers in the global floriculture market, valued both as a cut flower and a potted plant. Its inflorescence is characterized by a brightly colored, heart-shaped bract called the spathe and a central spadix densely packed with tiny flowers (Sumathi *et al*., 2018; Dufour and Guerin, 2005).

One of the major limitations in the commercial production of *A. andreanum* is the long vegetative phase, which typically delays the onset of flowering after planting (Wan *et al*., 2024). This lengthy period increases production costs and limits the flexibility of growers in meeting market demands. Therefore, strategies that promote vegetative growth and accelerate flowering are highly desirable in horticulture.

Among the techniques for improving plant performance, the use of plant growth regulators (PGRs) is particularly effective. PGRs significantly influence plant development, productivity, and flower quality (Farag et *al*., 2018; Muraleedharan *et al*., 2020). One such compound is BA, a synthetic cytokinin known to stimulate cell division, shoot proliferation, leaf expansion, and chloroplast development. It also enhances nutrient translocation and delays senescence by increasing chlorophyll content (Ibrahim *et al*., 2010; Eid, 2020).

Studies have shown that BA application improves morphological and physiological traits in several ornamental species. For example, in Asiatic lily, BA treatments significantly enhanced sprouting, vegetative growth, and leaf characteristics (Jayshree *et al*., 2020;

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Abbasi *et al*., 2020). In chrysanthemum, BA treatment also enhanced plant spread and branch number (Taranjit and Madhu, 2020).

In addition to growth regulators, mineral nutrition, particularly phosphorus and potassium, plays a key role in plant growth and reproductive development. Monopotassium phosphate (KH_2PO_4) is a water-soluble fertilizer that provides both phosphorus (P) and potassium (K), making it an efficient foliar nutrient source (Baiea *et al*., 2015; Luo *et al*., 2018). Phosphorus is involved in nucleic acid synthesis, cell division, root growth, and flowering, while potassium contributes to enzyme activation, osmotic regulation, photosynthesis, and disease resistance (Bader *et al*., 2021; Rao and Terry, 1989).

Recent studies highlight the benefits of MKP in enhancing flowering and biomass in ornamentals. Ma *et al*. (2021) demonstrated that optimal MKP concentrations significantly improved flower production and dry matter accumulation in *Rosa* spp. Similarly, phosphorus application has been linked to enhanced physiological functions under stress conditions, such as increased photosynthetic rate and water retention in *Viola cornuta* (Saputra *et al*., 2020). Adequate potassium nutrition has also been associated with increased plant biomass due to its role in stomatal regulation and water balance (Fahmi *et al*., 2020; Shehzad *et al*., 2020).

Considering the need for more efficient production strategies in horticulture, the application of BA and MKP may offer a promising approach to enhance growth and accelerate flowering in *A. andreanum*. Therefore, the main objective of this study was to evaluate the effects of different concentrations BA and MKP on enhancing vegetative growth, flowering, and physiological characteristics of *A. andreanum* with a particular focus on accelerating flowering to shorten the production cycle and improve commercial efficiency.

Materials and methods

Plant material, growth conditions, and experimental design: Uniform and disease-free seedlings of *A. andreanum* cv. Red were selected and transplanted into plastic pots (16 cm diameter × 14.5 cm height) filled with a standard substrate composed of cocopeat, peat moss, and perlite at a ratio of 30:30:40 (v/v). Prior to transplanting, the medium was homogenized and pre-moistened with distilled water.

The experiment was carried out in a greenhouse at the Department of Horticultural Sciences, Sari Agricultural Sciences and Natural Resources University (SANRU), Mazandaran, Iran. Temperature was maintained at 22 ± 2 °C during the day and 20 ± 2 °C at night, with 70–80% relative humidity. Light intensity in the greenhouse was approximately 15,000 lux, provided by a combination of natural sunlight and supplemental fluorescent lamps when needed.

The experiment was conducted as a factorial arrangement in a completely randomized design with three replications. The first factor was BA at concentrations of 0, 100, and 200 mg L^{-1} (Salehi Sardoei *et al*., 2018), which was applied as a foliar spray at 15-day intervals for four months. The second factor was MKP at concentrations 20% and 40% higher than the standard concentration in Hoagland nutrient solution, applied weekly via irrigation (Saputra *et al*., 2020). The base concentration of the Hoagland solution was prepared according to its standard composition, including defined amounts of nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, and other micronutrients. To prepare solutions with 20% and 40% higher MKP concentrations, the required amount of MKP was calculated by weight and added to the base solution.

Evaluated traits: Evaluated parameters included phenological (days to first flowering), morphological (number of flowers, number of leaves, leaf length, petiole length, spathe width, and root volume), physiological (chlorophyll *a*, chlorophyll *b*, total chlorophyll, carotenoids, and anthocyanins), and nutritional traits (leaf phosphorus and potassium content).

Spathe width was measured at the widest point using a digital caliper with an accuracy of 0.01 mm. Root volume was determined using the water displacement method. Roots were carefully removed from the growth medium, washed to remove adhering particles, and submerged in a graduated cylinder containing a known volume of water (V_1). The final water volume after submersion (V_2) was recorded, and root volume was calculated as $V_2 - V_1$, expressed in cm^3.

Photosynthetic pigments including chlorophyll *a*, chlorophyll *b*, total chlorophyll, and carotenoids, were extracted using 100% methanol following the method of Lichtenthaler and Buschmann (2001). Fully expanded young leaves were sampled and immersed in 8 mL of methanol in test tubes, kept in darkness at 30 °C for 24 hours. Absorbance was measured at 665.2, 652.4, and 470 nm using a spectrophotometer (Model: 80-3003-75, UK), and pigment concentrations were calculated using standard equations.

Anthocyanin content in spathe tissue was quantified using the pH differential method according to Giusti and Wrolstad (2001). One gram of fresh spathe tissue was homogenized in 25 mL of methanol containing 1% HCl and incubated in darkness at 4 °C for 24 hours. The extract was filtered, and absorbance was recorded at 530 and 657 nm using a spectrophotometer.

Leaf phosphorus content was determined using the vanadate–molybdate colorimetric method (Jackson, 1973). One gram of dried leaf powder was ashed at 550 °C for 4 hours in a muffle, and the ash was dissolved in 2 N HCl and diluted to 100 mL with distilled water. A 5 mL aliquot of the extract was mixed with 5 mL of ammonium molybdate–vanadate reagent and diluted to 25 mL. After 10 minutes of reaction at room temperature, absorbance was measured at 470 nm using a UV–Vis spectrophotometer (Model: Shimadzu

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UV-1800, Japan) with a 1 cm quartz cuvette. The spectrophotometer was calibrated daily using a series of phosphate standard solutions (0.0–2.0 mg P L^{-1}) to generate a standard curve with an $R^2 > 0.999$, and all measurements were performed in triplicate. Leaf potassium concentration was determined using a flame photometer (Model: PFP7, Jenway, UK; detection limit 0.1 mg L^{-1}, precision ±1%). Dried leaf samples were ashed at 500 °C for 5 hours in a muffle furnace, dissolved in 2 N HNO_3, filtered, and appropriately diluted. The flame photometer was calibrated before each use with potassium standard solutions (0, 1, 2, 5, 10 mg K L^{-1}), and all measurements were conducted in triplicate.

Statistical analysis: Data were analyzed using analysis of variance (ANOVA) via SAS software (version 9.4). Treatment means were compared using the least significant difference (LSD) test at the 5% probability level.

Results

Days to first flowering: The application of BA and MKP significantly affected the number of days until the first flowering in *A. andreanum* (Table 1). Control plants, which received no MKP or BA, took the longest time to flower with an average of 111.75 days. Tratments involving either MKP or BA alone slightly reduced this period. However, combined applications of both compounds at higher concentrations led to a notable acceleration in flowering. The earliest flowering was observed in plants treated with 40% MKP together with 200 mg L^{-1} BA, which flowered in just 77.25 days. This represents a reduction of nearly 31% compared to the control. Similarly, treatments with 40% MKP alone and 20% MKP combined with 100 mg L^{-1} BA shortened the flowering time by about 25% and 22 %, respectively (Fig. 1A).

Number of flowers: Both BA and MKP had a significant impact on the number of flowers per plant (Table 1). The lowest flower count was recorded in untreated plants, averaging just one flower per plant. The most substantial improvement was found when both compounds were applied together. In particular, plants treated with 40% MKP in combination with either 100 or 200 mg L^{-1} BA produced an average of 2.75 flowers, which is a 175% increase over the control. Additionally, the treatment combining 20% MKP with 200 mg L^{-1} BA yielded 2.25 flowers, corresponding to a 125% increase (Fig. 1B).

Spathe width: Spathe width was significantly influenced by the treatments (Table 1). The narrowest spathes, measuring 5.15 cm, appeared in control plants without any BA or MKP. Increasing the levels of MKP and BA resulted in wider spathes. The widest spathes, averaging 6.52 cm, were observed in plants receiving 40% MKP together with 200 mg L^{-1} BA, representing a 26.5% increase compared to controls. Treatments with 40% MKP alone and 20% MKP combined with 200 mg L^{-1} BA also produced wider spathes, with increases of approximately 17% (Fig. 1C).

Number of leaves: The number of leaves was significantly affected by different concentrations of BA and MKP (Table 1). The lowest number of leaves (3.25) was recorded in control plants. Application of 20% MKP alone increased the leaf number to 5, representing a 54% increase compared to the control. The combination of 20% MKP with 100 mg L^{-1} BA produced the highest number of leaves (6.75), which corresponds to a 107% increase relative to untreated plants. Moreover, treatments with 40% MKP alone and with 20% MKP + 200 mg L^{-1} BA resulted in 5.5 and 4.25 leaves, respectively (Fig. 2A).

Leaf length: Leaf length was also significantly influenced by the treatments (Table 1). In the control group, the average leaf length was 10.82 cm. The highest leaf length (13 cm) was recorded in plants treated with 40% MKP alone, showing an approximately 20% increase over the control. Combination treatments such as 40% MKP + 200 mg L^{-1} BA and 20% MKP + 100 mg L^{-1} BA also enhanced leaf length, reaching 12.65 cm and 12.87 cm, respectively (Fig. 2B).

Petiole length: Petiole length varied significantly among treatments (Table 1). The shortest petiole (10.67 cm) was observed in the control plants. The longest petiole length (15.07 cm) was achieved in plants treated with 40% MKP combined with 200 mg L^{-1} BA, representing a 41% increase compared to the control. The treatment with 20% MKP + 200 mg L^{-1} BA also resulted in a notable increase, with an average petiole length of 14.5 cm (Fig. 2C).

Root volume: The interaction between BA and MKP had a significant effect on root volume (Table 1). The lowest root volume (10.50 cm^3) was recorded in the control plants. The highest root volume (21.00 cm^3) was observed in plants treated with 40% MKP combined with 200 mg L^{-1} BA, representing a 100% increase compared to the control. In addition, substantial increases were recorded in the treatments combining 40% MKP with 100 mg L^{-1} BA and 20% MKP with 200 mg L^{-1} BA, in order, with root volumes of 20.50 and 20.00 cm^3, respectively (Fig. 3).

Photosynthetic pigments: The total chlorophyll content of *A. andreanum* was significantly affected by the interaction between BA and MKP at the 1% probability level (Table 2). The lowest total chlorophyll content was recorded in the control treatment (0.180 mg g^{-1} FW). The highest value was obtained from the application of 200 mg L^{-1} BA combined with 20% MKP, reaching 0.321 mg g^{-1} FW, which was approximately 78% higher than the control (Fig. 4A).

Chlorophyll *a* and chlorophyll *b* also responded positively to BA and MKP application. Chlorophyll *a* content ranged from 0.136 mg g^{-1} FW in control plants to 0.257 mg g^{-1} FW in plants treated with 20% MKP + 200 mg L^{-1} BA, which represents an 89% increase. Chlorophyll *b* content increased from 0.044 mg g^{-1} FW in the control to 0.065 mg g^{-1} FW in plants treated with

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Table 1. Analysis of variance for the effects of BA, MKP, and their interaction on growth and flowering traits of Anthurium

Root volume	Petiole length	Leaf length	Number of leaves	Spathe width	Number of flowers	Days to First flowering	df	Sources of variation
164.69**	25.46**	3.34**	8.44**	0.33*	2.77**	1919.52**	2	BA (A)
55.02**	5.84**	3.01**	4.77**	2.49**	4.19**	805.77**	2	MKP (B)
4.23*	1.66**	0.94*	2.23**	0.22*	0.69**	181.31**	4	A×B
1.08	0.38	0.38	0.37	0.06	0.16	1.39	27	Error
6.38	5.01	5.13	13.12	4.50	23.70	1.22		CV (%)

**Significant at 1% level of probability, *Significant at 5% level of probability, ^{ns} No significant difference

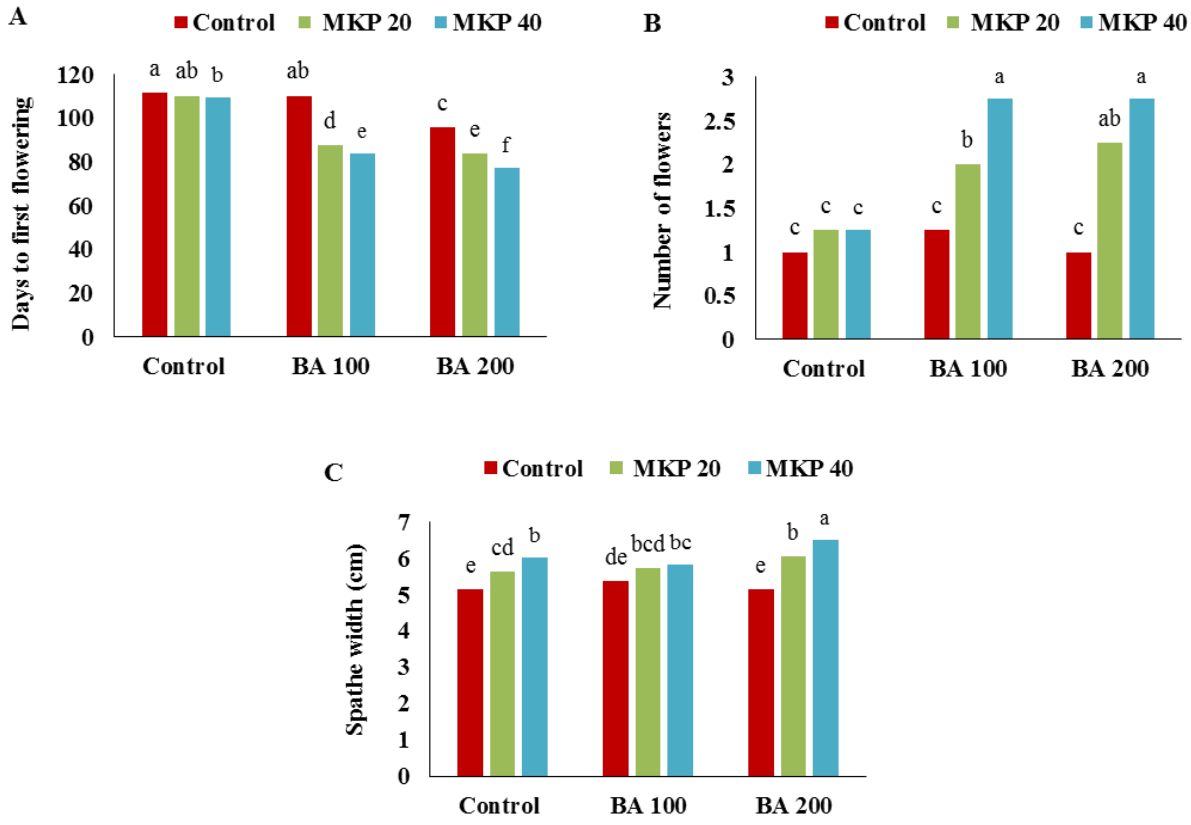

Figure 1. Effects of benzyl adenine (BA; mg L^{-1}) and monopotassium phosphate (MKP; %) on: (A) days to first flowering, (B) number of flowers per plant, and (C) spathe width. Different letters indicate statistically significant differences among treatments at P< 0.05 according to the LSD test.

Table 2. Analysis of variance for the effects of BA, MKP, and their interaction on pigments and leaf mineral content of Anthurium

Potassium	Phosphorus	Anthocyanins	Carotenoids	Chlorophyll *b*	Chlorophyll *a*	Total chlorophyll	df	Sources of variation
0.33**	0.016**	0.34**	0.50**	0.00028*	0.0059**	0.0085**	2	BA (A)
0.26**	0.00032^{ns}	0.04**	0.11**	0.00050**	0.0055**	0.0093**	2	MKP (B)
0.09*	0.0058**	0.29**	0.07**	0.00035**	0.0043**	0.0048**	4	A×B
0.032	0.00045	0.0055	0.00094	0.000053	0.000063	0.00011	27	Error
13.40	7.28	6.47	1.98	14.47	3.73	4.02		CV (%)

**Significant at 1% level of probability, *Significant at 5% level of probability, ^{ns} No significant difference

40% MKP + 100 mg L^{-1} BA — about 48% higher than untreated plants (Figs. 4 B and C).

The carotenoid content was significantly influenced by the interaction between BA and MKP (P< 0.01). The highest concentrations were recorded in plants treated with 20% MKP + 100 mg L^{-1} BA and 40% MKP + 100 mg L^{-1} BA, with values of 1.831 and 1.803 mg g^{-1} FW, respectively. These treatments resulted in increases of 54.2% and 51.9%, respectively, compared to the control (Fig. 4D).

Anthocyanin content: The anthocyanin content in the spathe of *A. andreanum* was significantly affected

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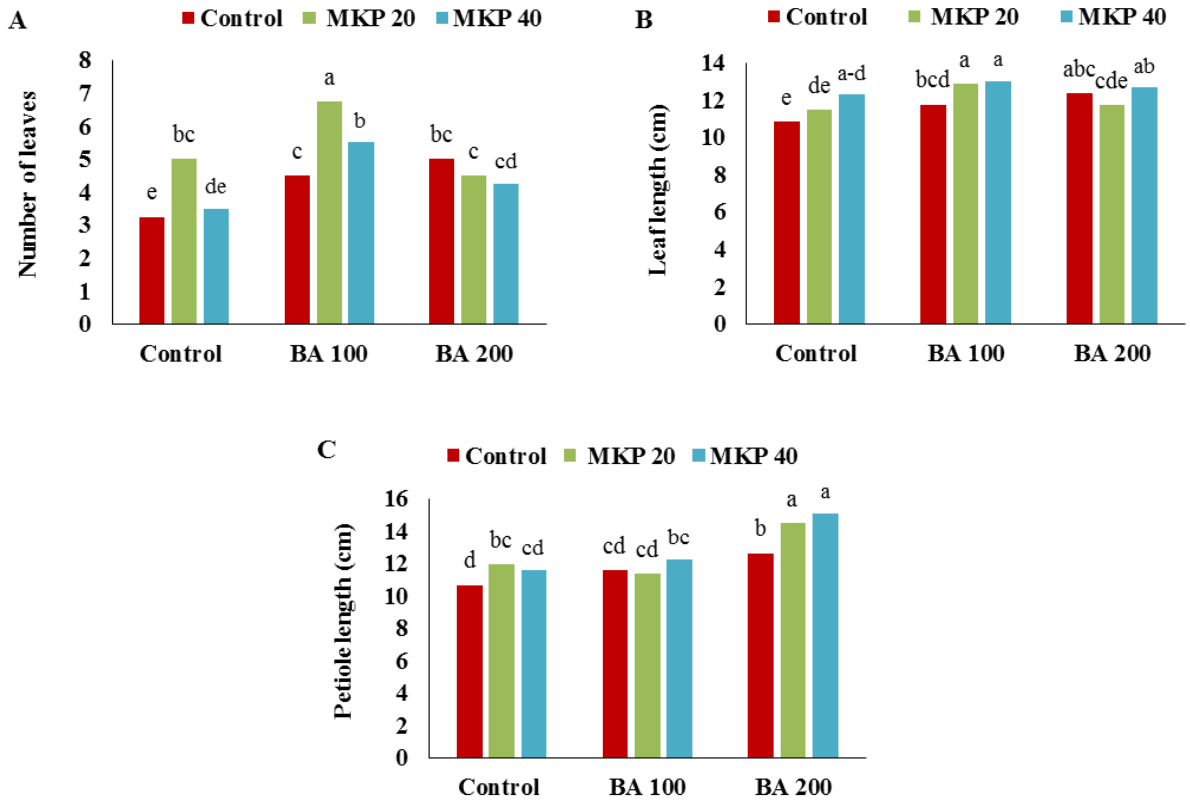

Figure 2. Effects of benzyl adenine (BA; mg L^{-1}) and monopotassium phosphate (MKP; %) on: (A) number of leaves, (B) leaf length, and (C) petioles length. Different letters indicate statistically significant differences among treatments at P< 0.05 according to the LSD test.

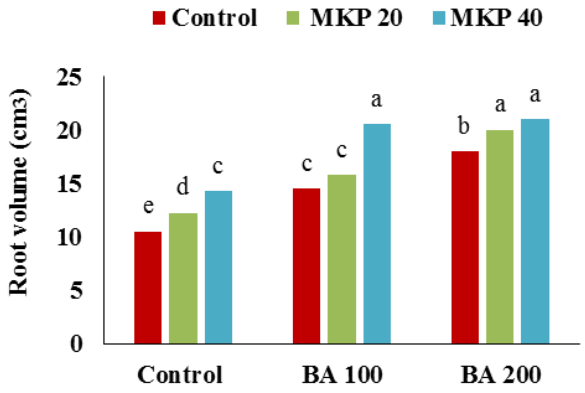

Figure 3. Effects of benzyl adenine (BA; mg L^{-1}) and monopotassium phosphate (MKP; %) on: root volume. Different letters indicate statistically significant differences among treatments at P< 0.05 according to the LSD test.

by different concentrations of BA and MKP (Table 2). The highest anthocyanin content (1.570 mg g^{-1} FW) was recorded in plants treated with 40% MKP + 200 mg L^{-1} BA, representing a 52% increase compared to the control (0% MKP + 0 mg L^{-1} BA, 1.032 mg g^{-1} FW). Following this treatment, the next highest anthocyanin content was observed in plants treated with 100 mg L^{-1} BA + 40% MKP, which did not differ significantly from the 200 mg L^{-1} BA + 40% MKP treatment (Fig. 5).

Leaf phosphorus and potassium content: Phosphorus content in the leaves of *A. andreanum* was significantly affected by varying concentrations of BA and MKP (Table 2). The highest phosphorus concentration (0.347%) was recorded in plants treated with 100 mg L^{-1} BA without MKP, representing a 24% increase compared to the control (0.281%). Treatments combining 20% MKP with 200 mg L^{-1} BA and 20% MKP with 100 mg L^{-1} BA also showed increases of

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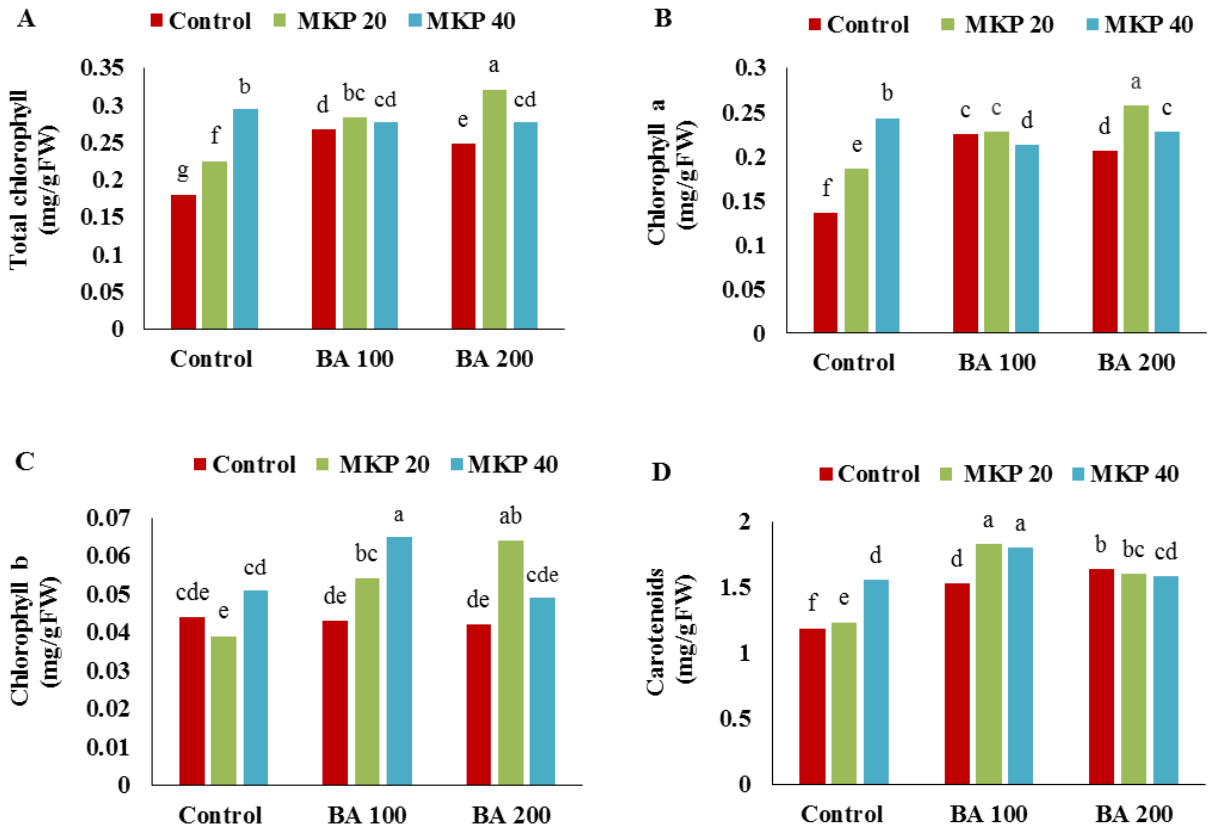

Figure 4. Effects of benzyl adenine (BA; mg L^{-1}) and monopotassium phosphate (MKP; %) on: (A) total chlorophyll, (B) Chlorophyll *a*, (C) Chlorophyll *b* and (D) carotenoid content. Different letters indicate statistically significant differences among treatments at P< 0.05 according to the LSD test.

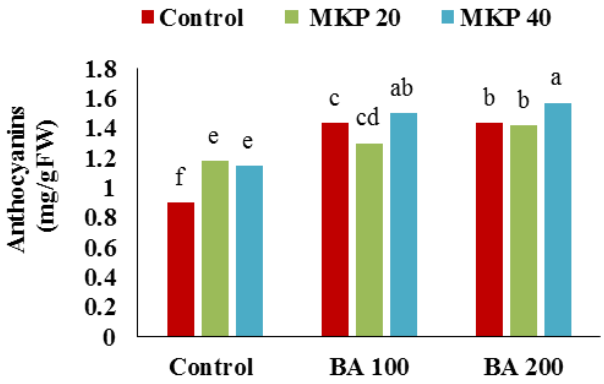

Figure 5. Effects of benzyl adenine (BA; mg L^{-1}) and monopotassium phosphate (MKP; %) on anthocyanin content. Different letters indicate statistically significant differences among treatments at P< 0.05 according to the LSD test.

18% and 18%, respectively (Fig. 6A).

Leaf potassium content was significantly influenced by the treatments (Table 2). The maximum potassium concentration (1.665%) was observed in plants treated with 40% MKP + 200 mg L^{-1} BA, which corresponds to a 43% increase over the control (1.170%). This was followed by 40% MKP + 100 mg L^{-1} BA (1.652%) and 20% MKP + 100 mg L^{-1} BA (1.605%), with increases of 41% and 37%, respectively (Fig. 6B).

Discussion

The present study demonstrated that the combined foliar application of BA and MKP significantly enhanced various growth, flowering, pigment, and mineral nutrient traits in *A. andreanum* cv. Red. The synergy between these two treatments resulted in considerable improvements compared to untreated controls, confirming their potential as effective growth regulators and nutrient sources in horticulture.

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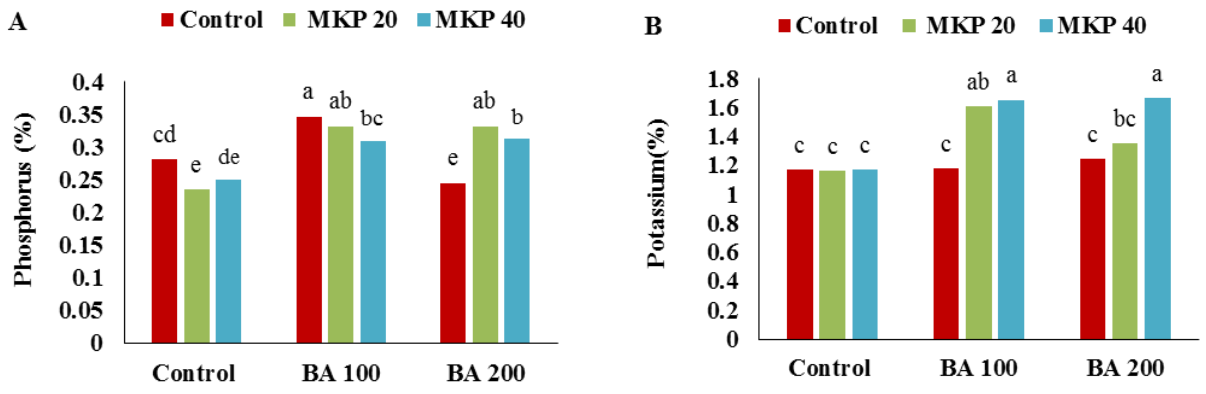

Figure 6. Effects of benzyl adenine (BA; mg L^{-1}) and monopotassium phosphate (MKP; %) on: (A) Phosphorus and (B) potassium Different letters indicate statistically significant differences among treatments at P< 0.05 according to the LSD test.

Flowering in *A. andreanum* was significantly accelerated under the highest concentrations of BA and MKP, indicating a strong synergistic effect of these treatments on reproductive development. This observation can be explained by the dual roles of cytokinins and phosphate–potassium nutrition. Cytokinins such as BA are known to stimulate cell division and promote the transition of vegetative meristems into floral meristems by regulating genes involved in floral induction pathways (Kieber and Schaller, 2014; Kapri *et al*., 2018). On the other hand, phosphorus and potassium supplied through MKP are directly implicated in energy metabolism, sugar translocation, and enzyme activation, all of which are critical for floral initiation and development (Malhotra *et al*., 2018; Taiz *et al*., 2015). The enhanced flowering response under combined BA and MKP treatments therefore suggests that BA may prime the meristem for floral differentiation, while MKP provides the metabolic resources necessary to support this developmental shift. Similar synergistic interactions between cytokinins and phosphorus–potassium fertilization have been reported in other ornamentals such as roses and lilies, where increased flower number and reduced flowering time were observed (Sijo *et al*., 2020; Jayshree *et al*., 2020; Ma *et al*., 2021). This highlights the potential of integrating plant growth regulators with balanced nutrition strategies to optimize flowering performance in *A. andreanum* cultivation.

Vegetative growth parameters, including leaf number, leaf length, and petiole length, also responded positively to BA and MKP treatments. The highest leaf number was recorded with the combination of 20% MKP and 100 mg L^{-1} BA, showing a remarkable 107% increase compared to control plants. This stimulation of leaf proliferation and expansion likely results from BA's known capacity to promote cell division and delay senescence, while MKP provides essential phosphorus and potassium nutrients that support growth (Schmulling, 2002; Majidian *et al*., 2012; Salehi Sardoei *et al*., 2014).

The increase in root volume, particularly under 40% MKP combined with 200 mg L^{-1} BA, indicates enhanced root system development, which is critical for nutrient and water uptake and overall plant vigor. Similar positive effects of MKP on root growth have been documented in rose plants (Ma *et al*., 2021). This stimulation of root proliferation can be attributed to the dual role of phosphorus and potassium and the synergistic effect of benzyl adenine. Phosphorus is a key component of ATP and nucleic acids, directly supporting cell division and elongation in root meristems, while potassium enhances osmotic adjustment and turgor-driven cell expansion, promoting root elongation and branching (Raghothama, 1999; Hafsi *et al*., 2014). Meanwhile, BA, as a synthetic cytokinin, stimulates cell division in actively growing meristematic tissues and promotes cellular differentiation, thereby enhancing both lateral and longitudinal root development (Kapri *et al*., 2018; Kieber and Schaller, 2014). Therefore, the combined application of MKP and BA provides not only the metabolic energy and ionic balance required but also the hormonal stimulus for robust root system development, which in turn improves water and nutrient uptake efficiency and overall plant vigor.

Application of BA and MKP significantly enhanced both photosynthetic pigments (total chlorophyll, chlorophyll *a* and *b*, carotenoids) and non-photosynthetic pigments such as anthocyanins in *A. andreanum*. The observed increase in chlorophyll and carotenoid content can be attributed to BA's ability to delay chlorophyll degradation and maintain chloroplast integrity by downregulating senescence-related genes and reducing oxidative stress (Zhang *et al*., 2023; Salehi-Sardoei *et al*., 2018). Concurrently, MKP provides readily available phosphorus and potassium, which are crucial for ATP production, enzyme activation, and other metabolic processes that support pigment biosynthesis (Ma *et al*., 2021). The pronounced accumulation of anthocyanins under combined BA and MKP treatments suggests a synergistic effect, likely

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enhancing secondary metabolite production and tissue photoprotection by scavenging reactive oxygen species and buffering against light-induced stress. This coordinated action of hormonal signaling and nutrient availability explains the significant improvement in pigment content and may also contribute to enhanced spathe coloration and ornamental value in *A. andreanum*.

Regarding mineral nutrition, the study revealed significant increases in leaf phosphorus and potassium contents following MKP treatments, consistent with MKP's role as a source of these macronutrients. Phosphorus is essential for energy transfer, root development, and flowering, while potassium regulates photosynthesis, enzyme activation, and osmotic balance (Malhotra *et al*., 2018; Shehzad *et al*., 2020). These nutrient improvements likely underpin the observed enhancements in growth and flowering traits. The increases of up to 43% in leaf potassium content and 24% in phosphorus content emphasize the nutritional benefit of MKP application in potted Anthurium cultivation.

In addition to MKP, the application of BA may have contributed to the improved mineral nutrient status of the leaves. As a synthetic cytokinin, BA is known to enhance nutrient mobilization and facilitate the translocation of minerals from roots to shoots by promoting phloem unloading and cell division in actively growing tissues (Prasad, 2022). Cytokinins can also delay senescence, thereby maintaining membrane integrity and the functional capacity of nutrient transport systems. Consequently, BA may have indirectly supported the accumulation of phosphorus and potassium in the leaves by enhancing overall nutrient use efficiency and sustaining metabolic activity in Anthurium plants (Zhang *et al*., 2023)

Conclusion

The findings of this study indicate that the combined application of BA and MKP markedly improves vegetative growth, flowering traits, pigment accumulation, and mineral nutrient uptake in potted *A. andreanum* 'Red'. Among the treatments, the combination of 200 mg L^{-1} BA and 40% MKP was the most effective, notably reducing the time to first flowering by approximately 31% and simultaneously increasing flower number, leaf development, root volume, and levels of chlorophyll, anthocyanins, phosphorus, and potassium. From a practical perspective, these results provide clear guidance for commercial Anthurium production. To shorten the flowering period, enhance flower quality, and promote overall plant vigor under greenhouse conditions, producers are recommended to apply BA as a foliar spray in combination with MKP as a nutritional supplement. This combined treatment offers a reliable approach to optimize both ornamental traits and flower quality, ultimately increasing productivity and economic value in Anthurium cultivation.

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