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Response of Vegetative and Flowering Growth of Common Myrtle (Myrtus Communis L.) to Pinching, Foliar Application of Benzyladenine and Compound NPK Fertilization

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ABSTRACT: Common myrtle (Myrtus communis L.) is a popular ornamental and medicinal evergreen shrub that is used for its attractive foliage, fragrant blossoms and essential oils. Its vegetative growth and flowering characteristics will have a significant impact on its commercial and landscape value and will need to be improved. Hence, the present study was performed to assess the effects of the combination of pinching, foliar application of benzyladenine (BA) and compound NPK fertilization separately on some vegetative and flowering characteristics of common myrtle. The experiment was designed as a factorial experiment with Randomized Complete Block Design (RCBD). The following treatments were tested: 2 pinching treatments (non-pinched and pinched), 3 concentrations of BA (0, 75 and 150 mg L^{-1}), and 3 NPK fertilizer levels (0, 5 and 10 g L^{-1}). The following characteristics were evaluated: plant height, leaf area, leaf number growth rate, average flower number, and flower diameter. All the experimental factors and their interactions were found to be significant for the evaluated traits. The plant height was the highest in non-pinched plants while pinching resulted in the highest leaf area, leaf number, flower number and flower diameter. The vegetative growth and flowering performance increased in a progressive manner as the level of BA and the NPK fertilizer was increased. However, the combination of the pinching with BA and NPK application with 150 mg L-1 and 10 g L-1 respectively, yielded the maximum number of leaves per plant (2908.7), flowers per plant (42.06) and flower diameter (1.98 cm). The plants with the highest BA and NPK rates resulted in the tallest plants (48.33 cm) while the lowest rates (1.00 cm) were from non-pinched plants. Finally, it can be concluded that the combination of pinching and foliar fertilization with 150 mg L^{-1} benzyladenine and 10 g L^{-1} NPK is an effective cultural practice to enhance vegetative growth, flowering performance and ornamental quality of Myrtus communis L. and thus it is recommended for use in commercial nursery production and landscape cultivation.

INTRODUCTION:

Common myrtle (*Myrtus communis* L.) is a significant perennial evergreen shrub from the Myrtaceae family, renowned in the Mediterranean region and Western Asia for its ornamental and medicinal uses. Esteemed for its dense growth, fragrant white flowers, attractive berries, and resilience to diverse growing conditions, myrtle's commercial value is influenced by factors such as vegetative vigor, branching patterns, flowering capability, and overall plant architecture. These attributes are shaped by genetic potential as well as environmental and horticultural practices including pruning, fertilization, irrigation, and the use

of plant growth regulators (Hartmann et al., 2018). Enhancing vegetative growth and flowering ability remains a priority in the ornamental myrtle industry.

Pinching, or shoot-tip removal, is a critical horticultural technique that reduces apical dominance by lowering auxin levels at the shoot apex, subsequently encouraging axillary bud growth and lateral branching—traits desirable for increasing canopy density and flower production (Cline, 1997; Al-Bayati & Salih, 2021). While it may diminish plant height, pinching can also lead to vigorous lateral shoot development (Taiz et al., 2015). Cytokinins like benzyladenine (BA) are vital growth regulators that facilitate cell division, chloroplast growth, nutrient mobilization, and shoot formation. BA has been widely recognized for its ability to stimulate axillary bud break, delay leaf aging, boost chlorophyll retention, and initiate flowers in ornamental specimens (Sakakibara, 2006; Al-Fatlawi et al., 2021). Studies indicate that BA application enhances shoot multiplication, expands leaf area, and promotes flowering by increasing meristematic activity and tissue sink strength (Davies, 2010; Werner et al., 2001). Thus, the integration of pinching and BA applications may yield synergistic effects by both attenuating apical dominance and fostering lateral bud development, thereby improving ornamental quality.

Mineral nutrition is essential for maximizing plant growth and flowering, with nitrogen (N), phosphorus (P), and potassium (K) playing crucial roles. Nitrogen is vital for synthesizing amino acids, proteins, nucleic acids, and chlorophyll, promoting strong vegetative growth. Phosphorus supports energy transfer, root development, and flower formation, while potassium regulates enzyme activation, carbohydrate translocation, osmotic adjustment, and stress resilience (Marschner, 2012; Mengel & Kirkby, 2001; Al-Bayati et al., 2023). Sufficient NPK fertilization in ornamental crops has been demonstrated to enhance biomass production, photosynthetic efficiency, nutrient absorption, flower yield, and overall plant quality (Havlin et al., 2014).

Despite numerous studies on pruning, BA, and mineral fertilization separately, limited research has focused on their combined effects on the vegetative growth and flowering responses of *Myrtus communis*. Understanding these interactions is essential, as the efficiency of growth regulators can depend on the plant's nutritional status, and pruning may alter hormonal balance and nutrient distribution. Therefore, the current study investigates the independent and synergistic effects of pinching, BA foliar spray, and NPK application on the growth and flowering performance of common myrtle. The findings are expected to inform nursery growers and landscape managers, yielding practical recommendations to enhance the quality and marketability of these plants.

MATERIALS AND METHODS:

The experiment was conducted from 5 May 2025 to 30 Jun 2026 at the Nursery of the Department of Horticulture and Landscape Design, College of Agriculture, Kirkuk University, Iraq. One-year-old plants of common myrtle (*Myrtus communis* L.) in uniform, healthy condition were selected for the study. The present experiment aims to investigate the effect of individual and combined application of pinching, benzyladenine (BA) and compound NPK fertilizer on vegetative and flowering growth of common myrtle (*Myrtus communis* L.). All plants were established under the same cultural conditions to reduce variability and to ensure uniform establishment prior to the initiation of the treatments. All experimental units were treated in the same way during the experimental period, with reference to standard horticultural practices such as irrigation, weed control and pest management.

The experiment was designed as factorial experiment using Randomized Complete Block Design (RCBD). Three experimental factors were investigated. The first factor was two treatments of pinching (P1 = no pinching and P2 = pinching). Pinching was done by cutting off the top shoot about 2-3 cm back from the growing tip when plants were well established. This practice was done with the aim of removing apical dominance and promoting the growth of lateral shoots. The second was the foliar application of a synthetic cytokinin (benzyladenine or BA) that is used extensively to increase cell division and shoot proliferation. The following concentrations of the BA were used: 0, 75 and 150 mg L^{-1}. The amount of required BA was dissolved in a small amount of ethanol and diluted with distilled water to form benzyladenine solutions. A few drops of a non-ionic surfactant were added to each solution to improve leaf coverage and absorption. Spraying foliar to ensure that complete wetting of foliage was made during early morning to minimize evaporation loss was performed until the end of the spraying period. Distilled water with the same amount of surfactant was used to spray the control treatment.

The third factor was the application of compound NPK fertilizer at three rates: 0, 5 and 10 g L-1. The fertilizer was made from the needed amount of water soluble compound fertilizer in water just before applying it. Fertilizer solution was supplied evenly around the root zone, at predetermined levels and at regular intervals during the experimental period. Equal irrigation

was applied immediately after fertilizer application to all plants for better movement of the fertilizer into the root zone and better nutrient availability to the plants. In this study eighteen combinations of two pinching treatments, three concentrations of BA and three levels of NPK fertilizer were used. Each treatment was repeated a few times in the experimental design and pots in a block were randomly positioned to minimize environmental variation among treatments.

Vegetative and flowering traits were determined at the end of the experimental period. The vegetative growth was measured by plant height (cm), the leaf area (cm^2) and the increase of leaf numbers of the main branches. Flowering was measured by the average number of flowers per plant and flower diameter (cm). The height of the plants was determined from the soil surface to the top of the plant by using a graduated ruler. The leaf area was measured by a leaf area meter, or by applying the standard method of calculation for leaves of Myrtle. The number of leaves on the main branches was determined by hand and the total number of fully opened flowers produced by each plant was counted during the flowering period. The diameter of the flowers was taken with a digital Vernier caliper from representative fully opened flowers taken from each experimental unit and averaged. These variables reflect the characteristics of the experimental results. The collected data were analyzed using an analysis of variance (ANOVA) which was based on the Randomized Complete Block Design (RCBD) suitable for factorial design to see the effect of pinching, benzyladenine, NPK fertilizer and their interactions. The statistical analysis with the experimental tables indicated that whenever the significant treatment effect was noted, the treatment means were separated by Duncan's Multiple Range Test at 5% probability ($P \leq 0.05$).

RESULTS AND DISCUSSION:

The results in Table 1 indicated that the effect of pinching, benzyl adenine (BA) and NPK fertilizer as well as their interactions were significant in affecting plant height. In general, the height of non-pinched plants (P1) were taller than the pinched plants (P2). The tallest plants (48.33 cm) were the plants not pinched and fertilized with 150 mg L^{-1} BA, the shortest plants (22.66 cm) were the plants that were not pinched and not fertilized. The plants tended to grow taller after application of both BA and NPK fertilizers, which may be a combination of the increase in cell division and elongation, and the increase in the availability of the nutrients and hence the more vegetative growth of the plants.

Plant height was significantly influenced by pinching, Benzyl adenine (BA) fertilization, and their interaction, as discussed in Table 1. The non-pinched plants showed superior height growth, this could be because the apical dominance is not being suppressed and auxin is secreted at the shoot apex, promoting stem elongation. Pinching resulted in shorter plants due to the removal of assimilates from growth to lateral shoots. These results are similar to the results of Cline (1997) who proposed that dominance and shoot growth patterns were affected by apical bud removal due to reduced auxin mediated dominance. The effect of BA on plant height promotion could be connected to the fact that BA acts as a cytokine to stimulate cell division and metabolic activity in meristematic tissues (Sakakibara, 2006). Moreover, the positive role of NPK fertilizers can be explained by the role of nitrogen in the synthesis of chlorophyll and protein, the role of phosphorus in energy transfer and the role of potassium in enzyme activation and water balance (Marschner, 2012). Ali et al. (2020) demonstrated that ornamental plants exhibited vegetative growth when they were grown with the use of cytokines along with nitrogen fertilization.

Table 1: Effect of Pinching, Spraying with Benzyl adenine, NPK and their interaction on the length of the plant (cm)

Pinching	BA mL^{-1}	NPK gL^{-1}			P * BA
		0	5	10	
P_1	0	22.66 k	26.33 j	31.66 h	26.88 d
	75	32.33 h	37.00 e	41.33 c	36.88 b
	150	39.00 d	43.33 b	48.33 a	43.55 a
P_2	0	27.00 j	32.00 h	35.00 fg	31.33 c
	75	29.00 i	33.33 hg	32.66 h	31.33 c
	150	32.00 h	36.66 fe	41.33 c	36.66 b
					Pinching effect
P * NPK	P_1	31.30 d	35.55 b	40.44 a	35.78 a
	P_2	29.33 e	34.00 c	36.33 b	33.22 b

					BA effect
BA * NPK	BA_1	24.83 h	29.16 g	33.33 e	29.11 c
	BA_2	30.66 f	35.16 d	37.00 c	34.27 b
	BA_3	35.50 d	40.00 b	44.83 a	40.11 a
NPK effect		30.33 c	34.77 b	38.38 a	

BA = BeNZYL Adenine, the letter-similar means for each factor individually and their interactions do not differ significantly according to Duncan's polynomial test at a probability level of 5%.

The data of Table 2 revealed that there were significant effect of pinching, BA concentration, NPK fertilization and their interaction on leaf area. Overall, the leaf area of the plants pinched was greater than that of the plants not pinched. Plants that were pinched and fertilized with 150 mg L-1 BA and 10 g L-1 NPK fertilizer had the highest leaf area (3.07) while the lowest leaf area was found (1.39) in the untreated plants. The promotion of cell expansion followed by the postponement of senescence observed with the use of BA may be involved in this stimulation of cell expansion and postponement of senescence that occurs in the leaves under NPK fertilization to enhance the efficiency of photosynthesis and the utilization of nutrients.

The pinching, application of BA and NPK fertilization caused significant increase in leaf area as discussed in Table 2. Overall, it may be concluded that pinched plants had a larger leaf area than non-pinched plants, presumably due to better assimilation being distributed to growing leaves when it was pinched. One reason for the improvement in leaf area after BA treatment may be that cytokines prevent leaf senescence and prolong the life of leaves for production of chlorophyll and photosynthesizing. Similar results were obtained by Guan et al. (2020) who showed that cytokines stimulated larger plant leaves and increased the amount of chlorophyll in the leaves. The NPK fertilizer also had an effect on leaf area development through the improvement of nutrient uptake and boost of photosynthetic activity. Leaf formation and biomass accumulation are closely dependent on good mineral nutrition which supplies the cell's metabolic processes and protein synthesis (Mengel & Kirkby, 2001).

Table 2: Effect of Pinching, Spraying with Benzyl adenine, NPK and their interaction on the Rate of increase in plant leaf area

Pinching	BA mL^{-1}	NPK gL^{-1}			P * BA
		0	5	10	
P_1	0	1.39 e	1.85 cde	1.90 b-e	1.71 b
	75	2.21 bcd	2.61 ab	2.17 bcd	2.33 a
	150	1.97 b-e	2.13 bcd	2.24 bcd	2.11 a
P_2	0	1.67 ed	2.42 bc	2.27 bc	2.12 a
	75	1.80 cde	2.08 b-e	1.95 b-e	1.94 ab
	150	1.59 de	2.26 bcd	3.07 a	2.30 a
					Pinching effect
P * NPK	P_1	1.86 bc	2.19 ab	2.11 ab	2.05 a
	P_2	1.68 c	2.25 a	2.43 a	2.12 a
					BA effect
BA * NPK	BA_1	1.53 d	2.13 bc	2.08 bc	1.92 b
	BA_2	2.00 bc	2.24 ab	2.06 bc	2.14 b
	BA_3	1.78 dc	2.19 bc	2.66 a	2.21 a
NPK effect		1.77 b	2.22 a	2.27 a	

BA = BeNZYL Adenine, the letter-similar means for each factor individually and their interactions do not differ significantly according to Duncan's polynomial test at a probability level of 5%.

The leaf number data presented in Table 3 showed that there were significant differences between the different treatments in the rate of increase of leaf number. Less leaves were found on the non-pinched plants (P1) compared to the pinched plants

(P2) and the effectiveness of the pinching on the lateral bud was observed in P2. The most favorable value (2908.7) was recorded in pinched plants under 10 g L-1 NPK fertilizer and 150 mg L-1 BA while the lowest value (772.7) was recorded in the untreated control ones. The synergistic effect of BA and NPK fertilizers on shoot production and vegetative growth could be responsible for the higher number of leaves.

Here, it is seen that the number of leaves increased significantly with the pinching, BA concentration and NPK fertilizer from the data presented in table 3. The number of leaves increased significantly when the terminal bud was removed, which was due to pinching, increasing the growth potential of the axillary buds and reducing the influence of apical dominance. This response resulted in an increase in the number of shoots which in turn resulted in an increase in the production of leaves. Cytokines were also reported to be responsible for the increased axillary bud growth and the initiation of shoots, by Davies (2010). The higher number of leaves after application of BA may be attributed to the stimulation of cell division in meristematic tissues and increase in sink strength of developing shoots. Furthermore, nutrients in NPK fertilizer encouraged the vegetative growth by giving nutrients for photosynthesis and metabolism. This agrees with the findings of Xu et al. (2021) who reported that plant vegetative growth and biomass production were greatly improved when using both BA and mineral fertilization.

Table 3: Effect of Pinching, Spraying with Benzyl adenine, NPK and their interaction on the Rate of increase in the number of leaves for the main branches

Pinching	BA mL^{-1}	NPK gL^{-1}			P * BA
		0	5	10	
P_1	0	772.7 f	965.0 fe	1107.0 c-f	948.2 c
	75	999.0 def	1242.0 c-f	1431.0 cde	1224.0 c
	150	1350.0 cde	1512.0 cd	1647.0 c	1503.0 b
P_2	0	945.0 fe	1296.0 c-e	1431.0 cde	1224.0 c
	75	1161.0 c-e	1485.0 cde	1535.7 cd]	1393.9 b
	150	1616.7 c	2416.3 b	2908.7 a	2313.9 a
					Pinching effect
P * NPK	P_1	1040.6 c	1239.7 bc	1395.0 b	1225.1 a
	P_2	1239.7 bc	1732.4 a	1958.4 a	1643.9 a
					BA effect
BA * NPK	BA_1	858.8 d	1130.5 bcd	1269.0 bc	1086.1 c
	BA_2	1080.0 cd	1363.5 bc	1483.0 b	1308.9 b
	BA_3	1483.3 b	1964.4 a	2277.8 a	1908.4 a
NPK effect		1140.7 c	1486.06	1676.7 a	

BA = BeNZYL Adenine, the letter-similar means for each factor individually and their interactions do not differ significantly according to Duncan's polynomial test at a probability level of 5%.

The average number of flowers produced per plant is significantly different among the treatments as indicated in Table 4. Consistently, pinched plants produced more flowers than did non-pinched plants. Pinching and application of 150 mg L^{-1} BA and 10 g L^{-1} NPK fertilizer gave the highest flowering response (42.06 flowers $plant^{-1}$) compared with 3.31 flowers $plant^{-1}$ in the untreated plants. The flower number increased significantly with the increase of BA concentration and was similar with NPK fertilizer level. Pinching, BA application and NPK fertilization in combination had the most flowering response, indicating that all three treatments together had a high impact on reproductive performance.

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Flower production is one of the important quality traits in ornamental plants that is greatly influenced by plant architecture, plant nutrition and hormonal regulation. The increase in flower production post pinching is likely due to increased laterals. New branches formed add another place for flowers to grow and therefore more flowers will form per branch. This is also in line with the other findings by Hartmann et al. (2018) who highlighted that pinching would help increase the branch density and flowering potential of the plants, which would improve the ornamental value of the plants. The promoting effect of benzyladenine on cell division, delay of senescence and assimilate partitioning towards reproductive parts are associated with its stimulatory effects. Cytokinins also stimulate metabolic activity of actively growing tissues, which leads to greater activity of flower meristems and better development of flower buds (Davies, 2010; Sakakibara, 2006). Higher levels of BA therefore resulted in a much higher number of flowers than plants without BA. Balanced NPK fertilization also improved flowering as mineral nutrients are needed in the continuous supply during the reproductive development. Nitrogen is important for the growth of the vegetative plant, providing a source of photosynthates to developing flowers; phosphorus is important for the initiation of flowers, particularly its role in energy transfer; potassium has also been shown to have a positive effect on carbohydrate translocation and flower quality (Marschner, 2012). Optimizing the levels of both hormones and mineral nutrition may create good physiological conditions for flower initiation and development in *Myrtus communis*, as the highest flower production was achieved from the combined application of pinching, BA and NPK.

Table 4: Effect of Pinching, Spraying with Benzyl adenine, NPK and their interaction on the Average Number of Flowers (flower plant^{-1})

Pinching	BA mL^{-1}	NPK gL^{-1}			P * BA
		0	5	10	
P_1	0	3.31 h	4.37 gh	5.39 fg	4.36 e
	75	13.32 ef	16.04 de	18.73 cd	16.03 d
	150	13.39 df	23.87 c	34.42 b	23.89 c
P_2	0	3.50 gh	6.12 fg	7.24 de	5.62 e
	75	14.07 cd	25.31 bc	36.24 b	25.21 b
	150	18.86 bc	30.71 b	42.06 a	30.54 a
					Pinching effect
P * NPK	P_1	10.01 e	14.76 d	19.51 c	14.76 b
	P_2	12.14 cd	20.71 b	28.51 a	20.46 a
					BA effect
BA * NPK	BA_1	3.41 f	5.25 ef	6.32 d	4.99 c
	BA_2	13.70 c	20.68 bc	27.49 ab	20.62 b
	BA_3	16.13 bc	27.29 ab	38.24 a	27.22 a
NPK effect		11.08 c	17.74 b	24.02 a	

BA = BeNZYL Adenine, the letter-similar means for each factor individually and their interactions do not differ significantly according to Duncan's polynomial test at a probability level of 5%.

Pinching, benzyladenine application, NPK fertilization and their interaction influenced significantly the diameter of flower (Table 5). Generally, plants that were pinched flowered larger than the non-pinched plants. The untreated non-pinched plants had the lowest flower diameter (1.65 cm) while the highest flower diameter (1.98 cm) was produced by the pinched plants treated with 150 mg L-1 of BA and 10 g L-1 fertilizer NPK. The flower diameter was increased with increasing BA

concentration and fertilizer level of NPK. Also, flower size produced as a result of the interactions of the three factors was greater than the individual treatments, suggesting that the combined treatments had a greater effect on flower development.

An important ornamental characteristic of flowers is the flower diameter which is of considerable commercial and aesthetic value because larger flowers tend to have greater value. The bigger the diameter of the flowers after pinching, the better the flower development and the better the distribution of assimilates to the lower number of dominant flower stalks, and the improvement of the lateral branches that are able to carry larger flowers. Pinching also positively affects the architecture of the canopy, which leads to higher light interception and photosynthetic efficiency and thus to better flower development (Hartmann et al., 2018). The use of benzyladenine was found to have a highly significant effect on flower diameter which is well known as a stimulator of cell division and cell expansion in floral tissues. Cytokinins help to keep developing flowers in an active state of metabolism, mobilize nutrients and delay senescence of tissues, thus enabling flowers to grow longer (Sakakibara, 2006). In many ornamental species, application of cytokinin resulted in larger flowers and better quality of the flowering plants in general (Davies, 2010). The increased flower diameter after NPK fertilization reveals the significance of an adequate mineral nutrition during the reproductive growth. Nitrogen is needed for protein synthesis and for the production of chlorophyll, while phosphorus is required for energy for flower development, and potassium is involved with regulating osmotic balance, enzyme activity and carbohydrate transport to the developing floral organs (Mengel & Kirkby, 2001; Marschner, 2012). This dual effect of pinching and BA and NPK resulted in the highest flower size since there was an interaction between the growth hormone effect of the BA and the higher nutrient levels provided by the NPK. The results corroborate the use of cultural practices combined with balanced fertilization and plant growth regulators as a promising approach to enhance the ornamental quality of common myrtle.

Table 5: Effect of Pinching, Spraying with Benzyl adenine, NPK and their interaction on the Flower Diameter (cm)

Pinching	BA mL^{-1}	NPK gL^{-1}			P * BA
		0	5	10	
P_1	0	1.65 g	1.69 f	1.74 de	1.69 d
	75	1.72 ef	1.78 cd	1.84 bcd	1.78 c
	150	1.78 bcd	1.80 bcd	1.86 bc	1.81 bc
P_2	0	1.68 fg	1.73 f	1.79 de	1.73 cd
	75	1.76 e	1.88 bcd	1.92 bcd	1.85 bc
	150	1.83 bc	1.94 ab	1.98 a	1.91 a
					Pinching effect
P * NPK	P_1	1.71 d	1.75 c	1.81 b	1.76 b
	P_2	1.75 cd	1.85 bc	1.89 a	1.83 a
					BA effect
BA * NPK	BA_1	1.66 f	1.71 e	1.76 cd	1.71 c
	BA_2	1.74 de	1.83 bc	1.88 b	1.81 b
	BA_3	1.80 b	1.87 ab	1.92 a	1.86 a
NPK effect		1.73 c	1.80 b	1.85 a	

BA = BeNZYL Adenine, the letter-similar means for each factor individually and their interactions do not differ significantly according to Duncan's polynomial test at a probability level of 5%.

CONCLUSION:

It was found that the vegetative and flowering ability of common myrtle (*Myrtus communis* L.) were significantly enhanced under the effect of pinching and the application of NPT fertilization and benzyladenine (BA) via foliar application. The procedure of pinching proved to be effective in the reduction of apical dominance and increase in lateral branching, leaf production and flowering potential. Benzyladenine application increased vegetative growth and flowering characteristics due to its cytokinin activity that stimulates cell division, shoot formation and flowering. Similarly, the NPK fertilization was useful to ensure good growth of the plants, because it provided them with the necessary nutrients for photosynthesis, metabolism and reproduction. The treatment of pinching in combination with 150 mg L^{-1} BA and 10 g L^{-1} NPK fertilizer gave the best results in all treatments with the highest values of leaf number, number of flowers and diameter of the flower. The results showed that the cultivation of the plants with suitable cultural practices in combination with plant growth regulators and balanced fertilizers can significantly enhance the ornamental value and marketability of plants of common myrtle. Thus, it is advisable that this therapy can be used in nursery and landscape growing of *Myrtus communis*.

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