

Physiological and chemical Response of *Rosa chinensis* to Foliar Application of Conventional and Nano NPK Fertilizers

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Abstract. A green house experiment was conducted to evaluate the conventional and nano NPK fertilizer (0, 1, and 2 g L⁻¹) on the physiological parameters of leaf mineral nutrient uptake (N, P, and K) and total phenolic compounds by *Rosa chinensis* plants. With two factors and three replicates, the experiment was structured using Duncan's Multiple Range Test for statistical significance. The results showed the significant superiority of the conventional NPK fertilizer. Most plants showed better physiological and mineral characteristics at the highest concentration (2 g L⁻¹). The treatment significantly enhanced dry matter accumulation by 60.33%, leaf nitrogen by 2.04%, and potassium concentrations by 2.17%. The treatment resulted in a pronounced increase in total phenolic compound contents of 18.73ppm. However, the nano-NPK fertilizer did not result in any significant difference under the given circumstances. The present research offers some new insights into the relative response of *Rosa chinensis* plants to regular and nano NPK fertilizers and demonstrates the effectiveness of regular NPK fertilizer as an appropriate nutrient management strategy.

Keywords: Dwarf rose, Conventional NPK, Mineral nutrition, Nano fertilizer, Physiological traits..

1. INTRODUCTION

Ornamental plants are increasing consistently because of their importance for urban environments and gardens. Such plants enhance functional value and aesthetics in landscapes [1]. Dwarf rose (*Rosa chinensis*) is considered one of the most economically and aesthetically important ornamental plants at both local and international levels. This plant is commonly used in landscaping, decorative arrangements, and commercial flower production because of its appealing blooms and ability to thrive in various environments [2]. In recent years, increasing demand for high-quality ornamental plants has encouraged researchers and growers to develop effective nutritional strategies capable of enhancing plant growth and flower quality while reducing production costs [3]. Crop yield and soil health benefit greatly from chemical fertilizers. Chemical fertilizers, used in conventional fertilization, often lead to environmental and agronomic problems for plants. These include low nutrient-use efficiency,

nutrient leaching into groundwater, and accumulation of soluble salts in the soil, all of which negatively affect soil fertility and environmental sustainability. The overuse of chemical fertilizers hardens the soil, reduces soil fertility, pollutes air, water, and soil, and depletes important soil nutrients and minerals, thereby posing environmental hazards [4]. Nanofertilizers have been proposed as an innovative method that will enable efficient use of fertilizers by providing controlled nutrient release, absorption, and delivery. Due to the nanoscale characteristics of such fertilizers, the efficiency in the process of uptake and usage of the nutrients can be higher, which will lead to increased productivity in plants while minimizing losses of nutrients and negative impact on ecology [5].

Nanofertilizers were also considered as a potential solution that will be capable of meeting the future requirements of agriculture through increased efficiency in the use of nutrients and resources [6]. The relationship between nano fertilizer and microorganisms in soil are attracting attention due to the vital role of the latter in nutrient cycles and growth of plants [7]. However, further research is required regarding the optimization of the way to apply such fertilizers, their concentration, and time [8]. The efficiency of fertilizer application is dependent on various parameters such as time, frequency of application, fertilizer concentration, and environmental conditions [9]. Moreover, the availability of nutrients is also largely dependent on pH levels, as nutrients such as nitrogen, phosphorus, and potassium become easily soluble under favorable pH conditions, leading to their efficient absorption by the plants [10,11]. Earlier experiments have shown that the application of nanofertilizer improves vegetative growth, floral attributes, fresh weight, and flower qualities. But there have been studies showing no statistically significant differences in macronutrients' accumulation by both types of fertilizers [12]. While there has been increased attention to the use of nano fertilizers, the information about the comparison between these fertilizers and traditional NPK fertilizers in terms of their physiological and nutritional impact on ornamental plants like *Rosa chinensis* is limited. In addition, the efficiency of the use of nano NPK fertilizers with certain concentrations under certain growth conditions has not been uniform, thus requiring further investigations. This study aimed to determine the influence of spraying dwarf rose (*Rosa chinensis*) with both nano and conventional NPK fertilizers on plant physiology, nutrient uptake, and phenolic content. It was hypothesized that the use of nano-NPK fertilizer would increase nutrient absorption efficiency and physiological performance compared with using conventional NPK fertilizer.

2. MATERIALS AND METHODS

2.1. MATERIALS

Experimental Site and Plant Materials

The experiment was carried out during the spring season of 2025 in a greenhouse at coordinates of 34.679852°N, 43.649759°E at the Department of Horticulture and Landscape, College of Agriculture, Tikrit University, Iraq. One year old dwarf rose plants (*Rosa chinensis*) of red and orange varieties were procured from a nursery. These plants were transplanted into greenhouse beds prepared for the experiments.

Experiment Design and Treatments

The experiment was arranged in a randomized complete block design with factorial arrangement. There were two main factors in the experiment namely; fertilizer types and fertilizer concentrations. Fertilizer types had three levels which included; control without any NPK fertilizer addition, conventional neutral NPK fertilizer and nano-NPK fertilizers. Fertilizer concentration had three different levels namely 0, 1 and 2 g L⁻¹. This resulted in nine combinations of treatments which were replicated three times leading to twenty seven experimental units.

Data Collection

The following parameters were evaluated:

Dry matter percentage (%): The plant samples undergo a drying process in an oven. They are kept at 65-80 degrees Celsius for 24-48 hours, or until their weight becomes constant.

Leaf nitrogen percentage (N%): According to Black et al. [13], the Kjeldahl method, following the Bremner method, is the established way to quantify total nitrogen in plant tissues.

Leaf phosphorus percentage (P%): The absorbance of the prepared plant sample is taken with a spectrophotometer at 880 nm, according to the Olsen method as detailed by Page et al. [14].

Leaf potassium percentage (K%): We can estimate the available potassium in plant tissues and leaves using a wet digestion assay with flame photometry, as described by Page et al. [14].

Total phenolic compounds (mg kg⁻¹): The total phenolic content was quantified using the Folin-Ciocalteu colorimetric assay, following the protocol of Kupina et al.[15].

Vase Life (days): Each experimental unit had three buds for bloom collected during the flowering stage. The specimens were submerged in a container holding 500 ml of distilled water mixed with 2% sugar. This was maintained at room temperature, and the water was replaced every two days. After cutting the flower stalk's slanted tip by 0.5 cm, the flowers were kept in the container until the outer petals drooped.

2.2. METHODS

Data Analysis

All the collected data was analyzed using analysis of variance (ANOVA) through the use of SPSS. Differences in means between treatments were evaluated using the Duncan's Multiple Range Test, which was done at a significance level of 5 percent ($p \leq 0.05$). Effects of fertilizer type, concentration, and their interaction was studied for all parameters measured.

3. RESULTS AND DISCUSSION

Nitrogen Content

The concentration of nitrogen in the leaves showed significant increments with increasing concentrations of NPK fertilizers. The highest nitrogen level (2.04%) was observed with the highest concentration of the fertilizer, while the lowest nitrogen values were found in the case of the control group (Table 1). This is due to the greater availability of nitrogen that

has been made available through the NPK fertilizer. Nitrogen is essential for the development of chlorophyll and proteins and enzymatic reactions [16,17].

Table 1. Effect of spraying with conventional and nano balanced NPK fertilizers and their interaction on nitrogen , phosphorus ,and potassium percentage (N,P, K%)

Nitrogen Content				
Conventional NPK concentrations (g L ⁻¹)	Nano NPK			Mean of conventional NPK
	N0	N1	N2	
F0	1.68 b	1.67 b	1.67 b	1.67 B
F1	1.73 b	1.72 b	1.72 b	1.72 B
F2	2.04 a	2.05 a	2.04 a	2.04 A
Mean of nano NPK	1.82 a	1.81 a	1.81 a	
Phosphorus Content				
Conventional NPK concentrations (g L ⁻¹)	Nano NPK			Mean of conventional NPK
	N0	N1	N2	
F0	0.37 a	0.36 a	0.38 a	0.37 A
F1	0.40 a	0.39 a	0.40 a	0.40 A
F2	0.38 a	0.37 a	0.39 a	0.38 A
Mean of nano NPK	0.38 a	0.37 a	0.39 a	
Potassium Content				
Conventional NPK concentrations (g L ⁻¹)	Nano NPK			Mean of conventional NPK
	N0	N1	N2	
F0	2.06 b	2.05 b	2.05 b	2.05 B
F1	2.11 ab	2.09 ab	2.11 ab	2.10 B
F2	2.16 ab	2.18 a	2.17 ab	2.17 A
Mean of nano NPK	2.11 a	2.11 a	2.11 a	

Values followed by the same letters are not significantly different according to Duncan's Multiple Range Test at $P \leq 0.05$.

Phosphorus Content

Phosphorus concentration did not differ significantly among treatments table1, with values ranging between 0.36% and 0.40%. This stability may indicate that the plants had already reached adequate phosphorus sufficiency levels under the prevailing experimental conditions.

Unlike nitrogen and potassium, the phosphorus mobility and accumulation in plant tissues are often slower and largely determined by nutrient absorption and movement within the roots [18 ,19,20]

Potassium Content

From table1.potassium concentration increased significantly in response to conventional NPK fertilization, with the highest values observed at the highest fertilizer concentration. Potassium plays a critical role in enzyme activation, stomatal regulation, osmotic adjustment, and translocation of carbohydrates. Adequate potassium supply therefore enhances plant vigor, dry matter accumulation, and stress tolerance [21,22] .

Dry Matter Percentage

The results revealed significant differences among treatments in dry matter accumulation. Conventional NPK fertilizer at the highest concentration (2g L^{-1}) produced the greatest dry matter percentage, reaching approximately 60.33%, compared with lower concentrations and untreated plants, presented in table 2. The increase in dry matter accumulation may be attributed to the essential roles of nitrogen, phosphorus, and potassium in stimulating photosynthesis, protein synthesis, and carbohydrate metabolism. Nitrogen is a major component of chlorophyll and amino acids, phosphorus participates in ATP-mediated energy transfer, whereas potassium regulates stomatal movement and translocation of assimilates.

These findings agree with previous studies indicating that balanced NPK fertilization improves nutrient-use efficiency and dry biomass accumulation in ornamental plants [23,24].

Phenolic Compounds

Table 2 showed conventional NPK fertilizer significantly increased total phenolic compound concentration compared with untreated plants. The increase in phenolic accumulation may be associated with enhanced secondary metabolism resulting from improved nutritional status.

Phenolic compounds are important antioxidant and defense-related metabolites, and their accumulation is often linked to improved plant tolerance against environmental stress [25].

Diameter of flower/mm

The results revealed significant differences among treatments in Diameter of flower/mm. Conventional NPK fertilizer at the highest concentration (1 g L^{-1}) produced the greatest Diameter of flower/mm, reaching approximately 39.80 mm, compared with lower concentrations and untreated plants, presented in table 2.

Flower Vase Life (days)

Table 2 showed that conventional NPK fertilizer significantly increased Flower Vase Life in days compared with untreated plants. The greatest vase life, approximately 14.33 days, was achieved with the highest concentration (2g L^{-1}), as detailed in table 2, compared to lower concentrations and untreated plants. A proper NPK fertilization plan extends the vase life of *Rosa chinensis*, through the development of sturdy cell walls, better carbohydrate storage, and managed water loss [26]. Adequate nutrition leads to sturdy stems that can withstand early wilting and petal loss. Research suggests that plant quality and lifespan are connected to NPK fertilizer use during active growth and phosphorus availability during larger blooms. [27]. We found that China Roses quality and vase life are enhanced by NPK fertilizer, which fosters robust stem growth, improves water retention in cells, and facilitates sugar transport during budding and blossoming.

Table 2. Effect of spraying with conventional and nano balanced NPK fertilizers and their interaction on the percentage of dry matter (%), Phenolic Compounds content (mg kg^{-1}), Diameter of flower/mm and Flower Vase Life (days)

Dry Matter Percentage

Conventional NPK concentrations (g L ⁻¹)	Nano NPK			Mean of conventional NPK
	N0	N1	N2	
F0	46.00 Ab	45.00 b	46.00 ab	45.66 b
F1	44.00 b	44.33 b	44.00 b	44.11 b
F2	61.33 a	60.00 ab	59.66 ab	60.33 a
Mean of nano NPK	50.44 a	49.77 a	49.88 a	

Phenolic Compounds

Conventional NPK concentrations (g L ⁻¹)	Nano NPK			Mean of conventional NPK
	N0	N1	N2	
F0	18.52 b	18.52 b	18.52 b	18.52 B
F1	18.72 a	18.71 a	18.72 a	18.72 A
F2	18.70 a	18.71 a	18.73 a	18.71 A
Mean of nano NPK	18.64 a	18.65 a	18.65 a	

Diameter of flower/mm

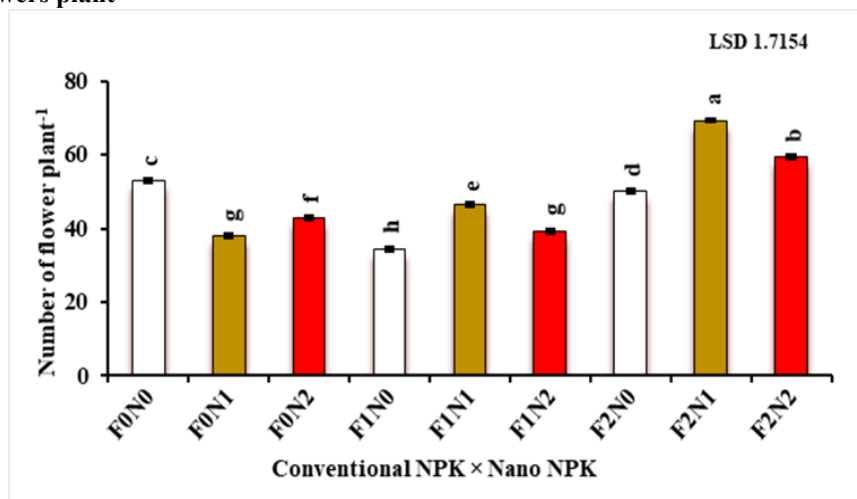
Conventional NPK concentrations (g L ⁻¹)	Nano NPK			Mean of conventional NPK
	N0	N1	N2	
F0	10.33 c	12.00 bc	13.00 abc	11.78 b
F1	11.67 bc	13.67abc	14.33 ab	13.22 ab
F2	12.67 abc	14.67 ab	15.67 a	14.33 a

Conventional NPK concentrations (g L ⁻¹)	Nano NPK			Mean of conventional NPK
	N0	N1	N2	
F0	36.10 d	35.20 e	35.06 e	35.45 b
F1	39.80 b	40.23 a	39.36 b	39.80 a
F2	37.80 c	41.13 a	40.03 a	39.65 a
Mean of nano NPK	37.90 b	38.85 a	38.15 a	
Mean of nano NPK	11.56b	13.44 a	14.33 a	

Flower Vase Life (days)

Duncan's Multiple Range Test at $P \leq 0.05$ level indicates no significant difference between values sharing the same letters.

Number of flowers plant⁻¹



Age of the flower \ day

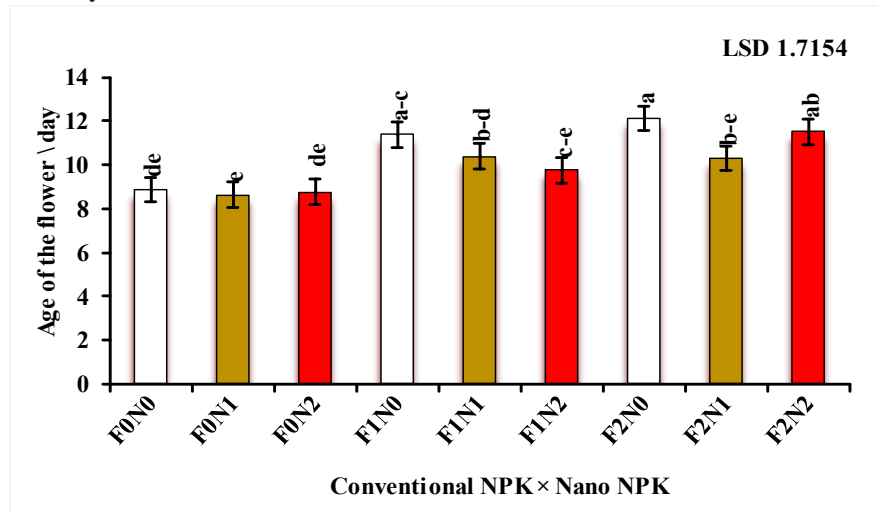


Fig. 1. Number of flowers plant⁻¹ and Age of the flower / day.

Numbers containing the same letters have no significant differences according to Least Significant Difference test at a probability level of (5%) (mean $\pm$ SE).

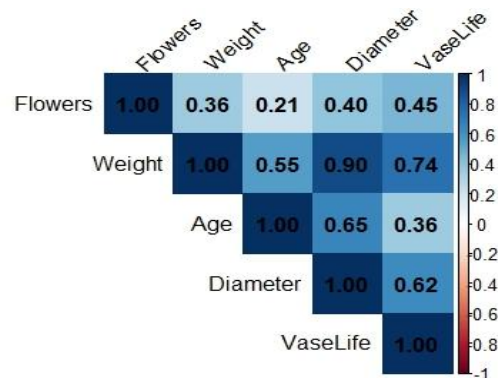


Fig. 2. From the heatmap above, it can be concluded that flower weight, flower diameter, and vase life have a significant correlation between each other. Flowers having larger diameters or more weight usually last longer than smaller ones in vases, and flower quantity shows minimal to moderate association.

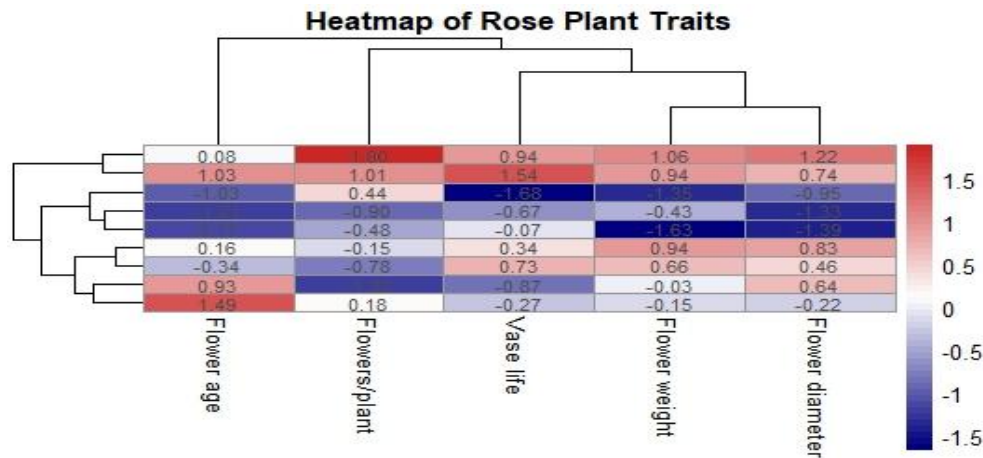


Fig. 3. Hierarchical Clustering Heat Map clearly shows that there is clear association among different rose plants traits. Rose flowers diameter and weight are placed closer together showing similarities among the two traits. Vase life is also grouped, large and heavy flowers have longer vase life. On the other hand, Flowers per plant and flower age are less associated with the above traits. From the above information, it is clear that the main determinants of vase life are flower size and flower weight.

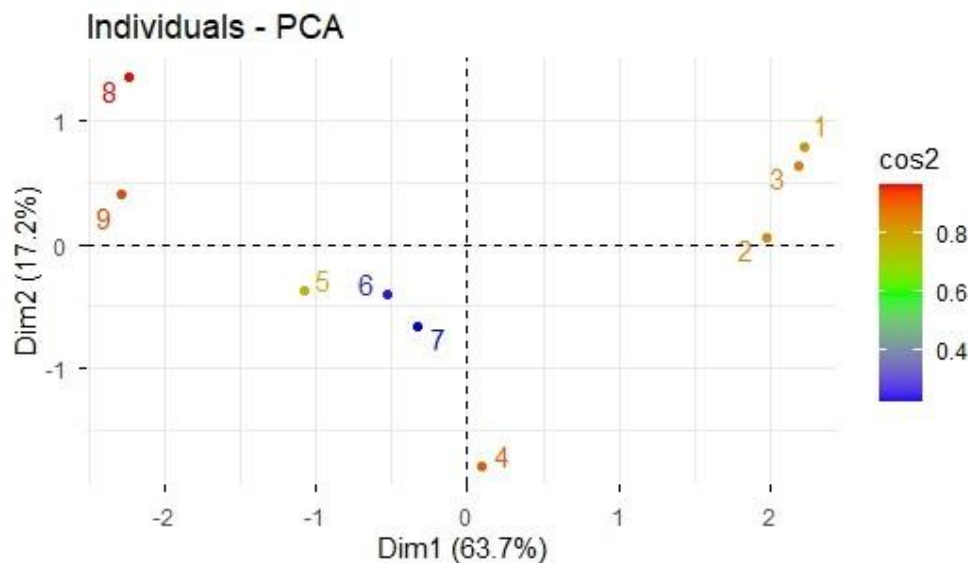


Fig. 4. The Principal Component Analysis (PCA) accounted for 80.9% of the variation based on the first two principal components (PC1 = 63.7%; PC2 = 17.2%). The results from the PCA score plot showed clear clustering of the samples due to the dissimilarities between the samples in relation to trait performance. Sample 1(F0N0), 2 (F0N1), and 3 (F0N2) grouped together and appeared to be more alike than sample 8 (F2N1) and 9 (F2N2), which formed another group. Sample Nos. 5 (F1N1), 6 (F1N2), and 7 (F2N0) exhibited some similarities and are found at the middle part of the graph. Sample No. 4 (F1N0) differed considerably from the others.

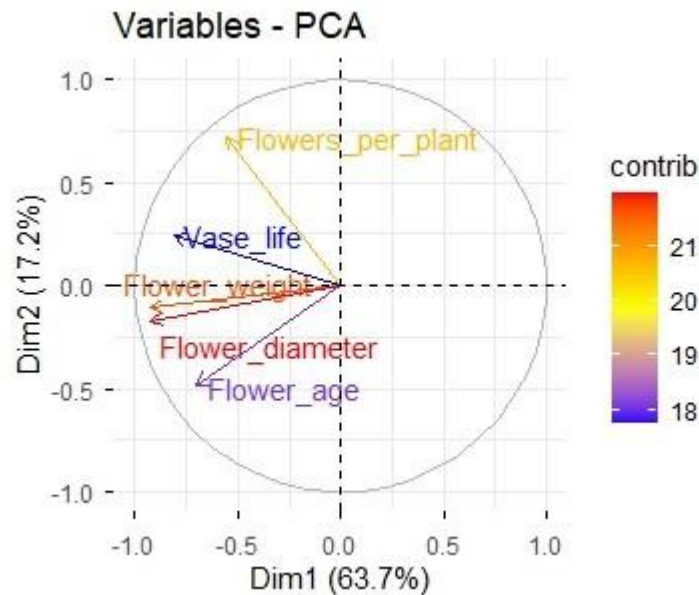


Fig. 5. This is a PCA variables plot. It is an illustration of how each of the initial variable is correlated with the first two principal components. The most prominent trend in the data (Dim1) contrasts plants that produce more flowers per plant (in the upper left), and plants with bigger and older flowers (on the left/lower left). It looks like flower weight is one of the most influential variable, and there is an opposite trend regarding Flowers per Plant compared to Flower age and Flower diameter.

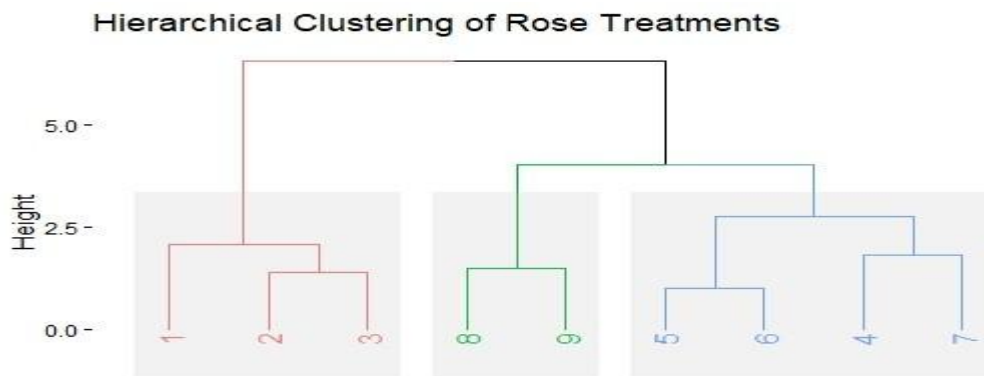


Fig. 6. The diagram is that of a dendrogram used in hierarchical cluster analysis. It classifies rose treatments according to their similarities. Group A: 1, 2, 3 Group B: 8, 9 Group C: 4, 5, 6, 7. Roses in each group act the same way, while those in different groups differ from one another. Of all the groups, Group 1, 2, and 3 are the most dissimilar from the others, while Group 8 and 9 resemble Group 4 to 7 the most.

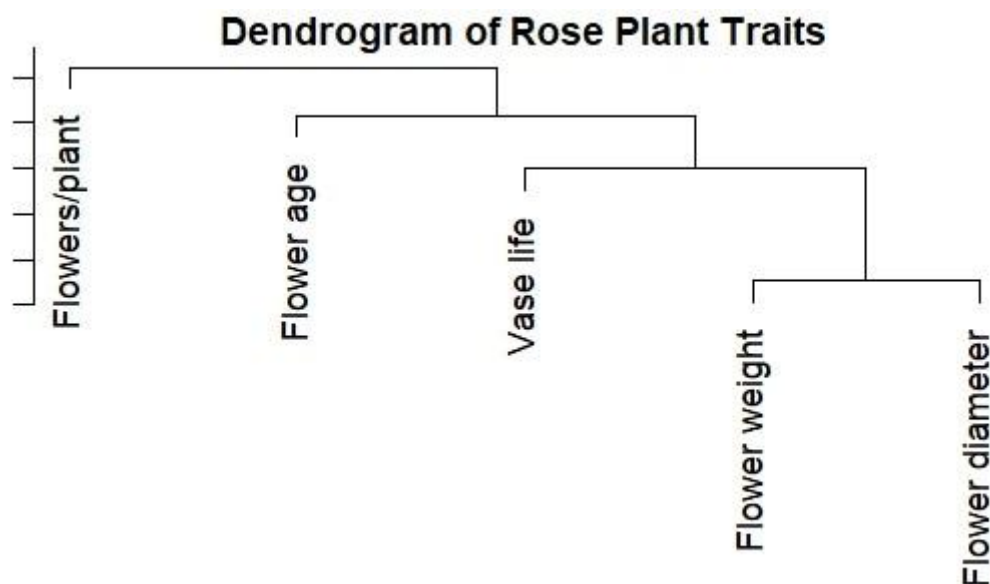


Fig. 7. This figure represents the dendrogram of rose plants. The properties have been clustered on the basis of their behavior among the rose plants. There could be some kind of tradeoff here since properties of flowers like flower weight and vase life are grouped together, but the flowers per plant seem independent from them.

Nano Fertilizer Performance

Although nano fertilizers are generally reported to improve nutrient absorption efficiency, the nano NPK treatments used in this experiment did not produce statistically significant improvements in most measured parameters. This outcome could be influenced by various elements such as fertilizer levels, the number of sprays, the size of nanoparticles, weather, and plants' responses. Thus, additional investigation is necessary before firm conclusions can be established about the success of nano-fertilization in dwarf rose cultivation [5,28].

4. CONCLUSIONS

In this study, foliar fertilization with mineral NPK fertilizer, especially with 2 g L⁻¹ concentration, led to better physiology and mineralization in the dwarf rose plants (*Rosa chinensis*). These positive changes were characterized by an increase in the accumulation of dry mass, nitrogen and potassium accumulation, and the creation of more phenolic compounds. Nano-NPK fertilizer could not make any significant differences in the conditions of this study. The lack of statistical difference in phosphorus concentration might have been due to sufficient phosphorus availability in all cases of this study. Therefore, mineral nutrition through the application of NPK fertilizer had beneficial effects on the growth and appearance of the dwarf rose plants. Future studies should examine various nano-fertilizers, concentrations, and application methods.

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DECLARATION OF COMPETING INTEREST

None

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