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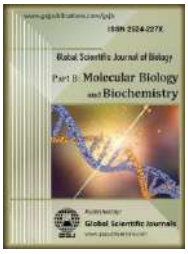

Vegetative Growth Parameters of Clove Plant *Dianthus Caryophyllus L* and Its Response to Salicylic Acid and Yeast Extract

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ABSTRACT

This factorial study was conducted in a nursery in Baghdad during the 2024-2025 agricultural season. It included three replicates and two treatments: salicylic acid (at two concentrations) and yeast extract (at three concentrations), Besides the control transaction which is zero. The aim of the experiment was to evaluate the physiological effects of spraying clove plants with two concentrations of salicylic acid (50 and 100 ppm), in addition to a control treatment (no spray). Three concentrations of yeast extract (4, 8 and 12 $g.L^{-1}$), in addition to the control treatment (without spraying), the number of experimental units was 36. The results showed that spraying with salicylic acid (50 and 100 ppm) had a clear positive role in the vegetative growth indicators of the current study, which are (plant height, root length, number of leaves, fresh and dry weight of both the vegetative and root systems). as it led to significant increases in the rates and values of these indicators compared to untreated plants. The yeast extract also had a significant and effective impact in improving these indicators, and the interaction between the two factors (acid and extract) also had a significant impact, as the combined treatment between concentrations of 100 ppm of acid and 12 $g.L^{-1}$ of extract recorded the highest values for all studied traits. While the lowest values were in the no-spray treatment for the study factors, which is the control treatment

1. Introduction

Ornamental plants are of great importance from a health and environmental perspective, as they purify the air, increase humidity, create reassurance, and reduce stress, in addition to aesthetic benefits, lowering temperature, developing responsibility, and stimulating creativity and psychological comfort (Wolverton et al., 1989) [1]. Carnation (Dianthus caryophyllus L.) [2] (Burich et al., 1996) is a globally important ornamental plant due to the beauty of its beautiful flowers and the long flowering period. It is a perennial plant but is grown as an annual in order to have high quality flowers. It can be produced year-round when environmental factors such as temperature, humidity and light are controlled in greenhouses. Therefore, it is a staple in the cut flower trade [3] (Hughes, 1993). It is one of the four most important cut flower plants in the world, and is characterized by the variety and beauty of those colors, so it is one of the plants

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used in gardens and basins, and its flowers are characterized by their sweet scent. Because of the advantages of its cut flowers commercially, the carnation has become an important global commercial crop. (Flora Holland 2014[4]. The Caryophyllaceae family includes 2,100 species, including 89 genera, including the genus Carnation. The latter includes 300 species found in Europe, Asia, and North Africa (Anon, 2002) [5]. Cloves are considered a medicinal, aromatic, and economic plant in Iraq. Clove oil is used as a medicine in the pharmaceutical industry, as a spice in the food industry, and in cosmetics (Hassan Bouraghdam, 2011) [6]. It contains polyunsaturated oils such as caryophyllene and eugenol, as well as other substances (Zucker, 2002) [7]. Cloves are used in the pharmaceutical industry as a fever reducer, heart tonic, pain reliever, memory enhancer, hair beautifier, and digestive enhancer (Al-Dajwi, 1996; Abu Zaid, 2000) [8][9]. Salicylic acid, which is moderately soluble in water but highly soluble in polar organic solvents, is a phenolic, aromatic carboxylic compound that occurs in the form of a crystalline powder [10] (Hamasas, 2013). It is a plant hormone of great importance in plant growth and development [11] (Raskin, 1992). It controls many physiological processes such as photosynthesis, root growth, stomata closure, flower formation, and transpiration [12] (Chandra et al., 2007). It is an inhibitor of abscisic acid [13] (Davies, 2004). Therefore, it is one of the internal plant hormones [14] (Hayat and Ahmed, 2007). Research has shown that treating plants with it increases dry matter [15] (Khadri, 2004), improves wheat growth and productivity when treated with it [16] (Shakirova, 2007), and increases plant growth and development [17] (Mahjoub and Zaghloul, 2012). Among the safe biofertilizers is baker's yeast (Saccharomyces cerevisiae), which provides plant nutrients free of pollutants or any environmentally harmful compounds. It is characterized by its abundance of amino acids. It is decomposed by its own enzymes upon dissolution, and the yeast extract releases many active compounds such as amino acids, vitamins, and minerals necessary for plant growth and vitality (Omran et al., 2000) [19]. It is a natural source of the hormone cytokinin and stimulates plant growth and development [20] (Amer, 2004) It has an effective and distinct role in vegetative growth due to its content of auxins and cytokinins and its effect on carbohydrate accumulation. [21] (Barnett et al., 1990) It stimulates cell division and elongation, protein synthesis, and the formation of chlorophyll and nucleic acids [22] (Desouki, 2007) [23] (Wanas, 2002). Treating wheat with yeast extract causes an increase in plant growth indicators, including wet and dry weight (Ibraheem et al., 2016) [24].

2. Materials and Methods

The experiment was conducted according to a completely randomized design, in one of the fields of Baghdad nurseries for the 2024-2025 growing season, as the clove seeds were planted on (10/12/2024), in plastic pots after the soil was prepared by grinding, sifting, weighing, placing it in the pots and fertilizing it. The number of experimental units was 36 experimental units. Salicylic acid concentrations were prepared (after preparing the main solution of the acid) according to the dilution law. Twenty days later (20 days after planting the seeds) in the early morning, the plants were sprayed with salicylic acid concentrations (50 and 100) and the control treatment was sprayed with distilled water. The next day, the plants were sprayed with yeast extract concentrations (4, 8 and 12) prepared in advance. The length of the root was measured from the beginning to the tip of the root using a graduated ruler. The leaves were counted and the weight of the green part as well as the root was measured using a sensitive balance. Then the green and root parts were dried in an electric oven until their weights were fixed, and their weights were recorded. The results were analyzed statistically according to the design of the study experiment and by the method (19). The averages were compared at a probability level of 0.05.

3. Results

plant height

The results of Table (1) showed that spraying cloves with salicylic acid led to a significant increase in plant height, as the average height increased from 8.69 cm at concentration 0 to 10.94 cm at concentration 100 ppm. The results are in agreement with It was also shown that the use of yeast extract led to a significant increase in plant height, especially at concentration 12 $g.L^{-1}$

compared to the control treatment, as the plant height increased from 8.33 to 11.00 cm As for the interaction between salicylic acid and yeast extract.

Table (1) showed a clear effect in enhancing this trait; the highest height value (12.50 cm) was recorded when using concentrations of 100 ppm of salicylic acid and 12 $g.L^{-1}$ of yeast extract, compared to the lowest value (5.05 cm) in the control treatment.

Tab (1) Effect spray salcylic acid and addition active yeast extract in plant height cm Cloves plant					
salcylic acid (ppm)	yeast extract concentrations ($g.L^{-1}$)				Effect the average salcylic acid (mM.L-1(
	0	4	8	12	
0	7.50	8.00	9.25	10	8.69
50	8.25	9.00	9.50	10.5	9.31
100	9.25	10.50	11.50	12.50	10.94
Effect theaavrage yeast extract	8.33	9.17	10.08	11.00	
LSD 0.05)	yeast extract = 0.124 salcylic acid = 0.213+ The interaction= 0.350				

Root Length:

Data in Table (2) indicated a significant effect of salicylic acid on increasing root length, increasing from 19.75 cm at a concentration of 0 to 23.06 cm at a concentration of 100 ppm.

Tab (2) Effect spray salcylic acid and addition active yeast extract in root length cm Cloves plant					
salcylic acid (ppm)	yeast extract concentrations ($g.L^{-1}$)				Effect the average salcylic acid (mM.L-1(
	0	4	8	12	
0	18.50	19.25	20.00	21.25	19.75
50	20.50	21.00	21.50	22.00	21.25
100	22.00	22.50	23.25	24.5	23.06
Effect theaavrage yeast extract	20.33	20.91	21.58	22.58	
LSD 0.05)	yeast extract = 0.451 salcylic acid = 0.124 The interaction= 0.541+				

Yeast extract also significantly increased root length when treated with the extract, particularly at a concentration of 12 g.L-^{1} . Root length reached 22.25 cm, compared to 20.33 cm in the control treatment. Regarding the interaction between the two factors, the treatment that included spraying with salicylic acid at a concentration of 100 ppm and yeast extract at a concentration of 12 g.L-^{1} achieved the highest average root length of 24.50 cm, compared to the control treatment, which recorded 18.50 cm.

Number of leaves

The results of Table (3) showed that increasing the concentration of salicylic acid from 0 to 100 ppm resulted in a significant increase in the number of leaves in carnation plants, from 31.75 to 86.25 leaves per plant. Furthermore, the concentration of 100 was superior to the concentration of 50, which yielded 53.75 leaves. The results also showed that the 12 g.L-^{1} yeast extract increased the number of leaves to 57.38, a 49.78% increase compared to the 0 concentration, which recorded 38.33 leaves per plant.

The interaction between salicylic acid and yeast extract was significant, with the highest number of leaves recorded in the 100 ppm salicylic acid + 12 g.L-^{1} yeast extract combination, at 104 leaves per plant, while the lowest value was recorded in the control (0 + 0) treatment, which recorded only 10 leaves.

Tab (3) Effect spray salcylic acid and addition active yeast extract in number leaves of Cloves plant

salcylic acid (ppm)	yeast extract concentrations (g.L^{-1})				Effect the average salcylic acid (mM.L-1(
	0	4	8	12	
0	10	25	42	50	31.75
50	40	45	55	75	53.75
100	65	85	91	104	86.25
Effect theaavrage yeast extract	38.33	51.67	62.67	76.33	
LSD 0.05)	yeast extract = 0.571 salcylic acid = 0.324 The interaction= 0.840				

wet weight of shoot

The results of Table (4) indicate that spraying with salicylic acid at concentrations of 50 and 100 ppm led to a significant increase in the fresh weight of shoot, with values reaching 4.88 and 8.75 g/plant, respectively, compared to 3.38 g/plant in the control treatment. The results are in agreement with [25](Knag et al. 2023). Yeast extract also significantly improved this trait, particularly at a concentration of 12 g.L-^{1} , where fresh weight increased from 1.67 to 10.00 g/plant compared to zero concentration. The two-way interaction demonstrated a clear cumulative effect, with fresh weight reaching 12.75 g/plant at a combined concentration of 100 mg salicylic acid and 12 g.L-^{1} yeast extract, representing a 96.42% increase over the control treatment, which yielded a minimum value of 0.50 g/plant.

wet weight of root

Tab (4) Effect spray salcylic acid and addition active yeast extract in wet weight shoot Cloves plant					
salcylic acid (ppm)	yeast extract concentrations ($g.L^{-1}$)				Effect the average salcylic acid (mM.L-1(
	0	4	8	12	
0	0.5	2.00	4.00	7.00	3.38
50	1.00	3.00	6.50	9.00	4.88
100	3.50	5.00	12.50	14.00	8.75
Effect theaavrage yeast extract	1.67	3.33	7.67	10.00	
LSD 0.05)	yeast extract = 0.304 salcylic acid = 0.347 The interaction= 0.660				

Table (5) showed the significant and positive effect of salicylic acid in increasing the fresh weight rate of clove roots. The highest rate recorded for this trait was at a concentration of 100 parts per million of the acid, with an increase of 243.16% compared to the zero concentration of the acid. The results of Table (5) also showed the effective role of the second factor, which is yeast extract, in increasing the rate of this trait, as the fresh weight of clove roots at a concentration of 12 g L-1 was 7.00 g/plant, compared to 1.51 g/plant when not treated with yeast As for the interaction between the two study factors, it was significant and positive in raising the adhesive values. The highest value of the wet weight of the roots was 10.00 g/plant when treated with 100 ppm of salicylic acid and a concentration of 12 g L-1 of yeast extract. The results of Table (5) showed that the lowest value (0.30 g/plant) was at zero concentration for both study factors. The results confirmed the positive role of both salicylic acid and yeast extract in increasing the wet weight of the root.

Tab (5) Effect spray salcylic acid and addition active yeast extract in wet weight weight root Cloves plant					
salcylic acid (ppm)	yeast extract concentrations ($g.L^{-1}$)				Effect the average salcylic acid (mM.L-1(
	0	4	8	12	
0	0.3	1.00	2.50	3.50	1.83
50	1.25	2.75	4.25	7.50	3.94
100	3.00	5.50	7.00	10.00	6.28
Effect theaavrage yeast extract	1.51	3.08	4.58	7.00	
LSD 0.05)	yeast extract = 0.211 salcylic acid = 0.301 The interaction= 0.512				

Shoot dry weight

The results of Table (6) confirmed the positive and significant effect of treatment with salicylic acid on the dry weight of the shoot, as the rate of the trait increased from 0.39 g/plant at a concentration of zero

to 0.76 g/plant at a concentration of 100 parts per million of the acid. These results were consistent with the results of (Knag et al. 2023). The effect of yeast extract was positive and significant on this trait, as the dry weight of the vegetative part increased from 0.33 to 0.79 g/plant when the concentration of yeast extract increased from 0 to 12 g.L-^{1}. The results of Table (6) showed that the interaction between salicylic acid and yeast extract had a significant effect on the dry weight trait of the shoot. The treatment of concentration of 100 ppm of salicylic acid and 12 g.L-1 of yeast extract was superior, giving the highest value for the dry weight of the shoot, which reached 0.91 g/plant, compared to the lowest value, which reached 0.12 g/plant in the control treatment, which confirms the role of the two factors in increasing the rates and values of the trait

Tab (6) Effect spray salcylic acid and addition active yeast extract in in dry weight shoot Cloves plant

salcylic acid (ppm)	yeast extract concentrations (g.L^{-1})				Effect the average salcylic acid (mM.L-1(
	0	4	8	12	
0	0.12	0.23	0.54	0.65	0.39
50	0.25	0.36	0.70	0.80	0.53
100	0.62	0.69	0.82	0.91	0.76
Effect theaavrage yeast extract	0.33.	0.43	0.69	0.79	
LSD 0.05)	yeast extract = 0.012 salcylic acid = 0.017 The interaction= 0.019				

Root dry weight

The dry weight rate of the root part increased significantly with the increase in the concentration of salicylic acid sprayed on the plant, and this is what the results of Table (7) showed. When the concentration of the acid increased from zero to 100 parts per million, the rate of the trait increased from 0.032 to 0.056 g/plant. The results are consistent with [25] (Knag et al. 2023). The yeast extract also had a significant and positive effect according to the results of Table (7), as the dry weight of the root part increased from 0.25 g/plant at zero concentration to 0.062 g/plant at 12 g.L-^{1} concentration, which confirms the positive role of the yeast extract in the growth of the root part. The results of the aforementioned table indicated the positive effect of the interaction between the two study factors (salicylic acid and yeast extract) in raising the dry weight values of the root part. The highest dry weight value of the root part was recorded when treating with a concentration of 100 parts per million of salicylic acid with a concentration of 12 g/liter of yeast extract, and it was 0.076 g/plant, compared to 0.017 g/plant when not treated with the two factors, when treating with the control.

Tab (7) Effect spray salcylic acid and addition active yeast extract in dry root Cloves plant					
salcylic acid (ppm)	yeast extract concentrations ($g.L^{-1}$)				Effect the average salcylic acid (mM.L-1(
	0	4	8	12	
0	0.017	0.026	0.037	0.048	0.032
50	0.023	0.035	0.054	0.062	0.044
100	0.036	0.049	0.064	0.076	0.056
Effect theaavrage yeast extract	0.025	0.037	0.052	0.062	
LSD 0.05)	yeast extract = 0.011 salcylic acid = 0.014 The interaction= 0.025				

4. Discussion

The positive effect of salicylic acid is attributed to its effective role in enhancing the absorption of essential nutrients such as nitrogen, phosphorus, potassium, and calcium[26] (Jalal et al., 2012). This compound also plays an important physiological role, contributing to the activation of ferredoxin, a key compound in photosynthesis. This compound plays a key role in reducing NADP to NADPH+H, both of which are essential for the formation of proteins, nucleic acids (RNA), sugars, and increased chlorophyll content. All of this directly impacts the efficiency of photosynthesis , which leads to enhanced vegetative growth indicators, such as increased leaf number, plant height, and fresh and dry weight of both the shoot and root system. Studies have also shown [27](Hafez, 2015), The increase in leaf area is also closely linked to the use of salicylic acid, due to its direct effect on the activity of physiological processes within the plant. On the other hand, yeast extract played a significant role in increasing the values and rates of growth indicators for the current study, because it activates vital activities within the plant. It has a significant role in improving metabolic activities by increasing the production of photosynthetic pigments (such as chlorophyll and carotenoids), and activating the enzymes responsible for this process, which contributed to enhancing plant growth and increasing the number of leaves and plant length [28](Ahmed et al., 2021). Which leads to an increase in the weight of the fresh plant and then the dry one.

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