Effect of Adding Chemical Fertilizer and Spraing Nano-Calcium on Some Vegetative and Root Characteristics of Cauliflower in Calcareous Soil

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Abstract

Cauliflower roots were used in an experiment that was conducted at the College of Agriculture, University of Diyala, during the fall agricultural season of 2020 in order to investigate the impact that chemical fertilizer and spraying with nano fertilizer had on the growth of the cauliflower roots. The recommended addition of two thirds of the total recommended amount, as well as the addition of the recommended amount of chemical fertilizer, which is three hundred kilograms per hectare, and three different levels of nano fertilizer (calcium oxide) with concentrations of zero, fifty, and one hundred parts per million (ppm). The treatments were dispensed in an international experiment with three replications in accordance with the design of randomized complete sectors (RCBD), and the results were compared using the Duncan test with a significance level of 0.05. The following is a summary of the findings from the experiment.The use of chemical fertilizer with the full recommendation led to a significant increase in the weight, length and root diameter of plant-1 it reached (77 gm plant-1, 17.55 cm and 4.62 mm), respectively. Spraying the nano-fertilizer at a concentration of 50 ppm led to a significant increase in the weight, length and diameter of the roots to 101 gm plant-1, 21.33 cm and 5.95 mm) compared to the control treatment, which recorded the lowest values were (81 g, 18.67 cm and 4.80 mm), respectively. While the interaction between the full recommendation of chemical fertilizer and nano fertilizer with a concentration of 50 ppm resulted in a significant increase in all studied traits.

Keywords: *chemical fertilizers, nano-fertilizer, cauliflower, calcareous soils.*

INTRODUCTION

Important during the colder months, cauliflower is a member of the Brassicaceae family, which consists of 338 genera and 3709 species that are dispersed across various regions of the world, particularly the temperate regions of the hemisphere. Cauliflower is a member of the cruciferous vegetable family (boras et al., 2006). It is the portion of the plant that is consumed, which consists of the flower buds that have not yet opened, along with the flower holders, both of which have expanded flesh (Al-Mohammadi and Al-Mishal , 1989). The edible section of a cauliflower has a significant nutritional value since it contains 91.7 grams of water, 2.4 grams of protein, 4.9 grams of carbs, 2.2 milligrams of calcium, 1.1 milligrams of iron, and several vitamins for every 100 grams (Khalaf Allah et al., 1985).

Chemical fertilizers are manufactured chemicals that improve plant nutrition (growth and increase production) in addition to improving the quality of the yield (Ali, 2012). As the use of chemical fertilizers leads to an increase in production to about 50%, provided that it is balanced when added, including major elements (NPK), which is considered important in the continuation of plant growth, especially in the phase of vegetative growth, flowering and nodes, at equal a concentration, chemical fertilizers are manufactured chemicals that improve plant nutrition (growth and increase production) (El-Shahat, 2007).

To be able to provide for the ever-increasing requirements of a population is one of the primary objectives of agricultural policy in every nation across the world. One of the most effective ways to achieve this objective is to boost the quantity and quality of agricultural output. Through the application of contemporary technology in agricultural settings, it is possible to boost the effectiveness of the utilization of materials or resources while causing only marginal harm to the production (Baruah and Dutta, 2009; Naderi and Danesh-Shahraki , 2013). Nanotechnology is one of these technologies that has the potential to revolutionize new science due to its ability to produce nanoparticles of different elements and be able to provide more benefits than regular molecules. This ability gives nanotechnology the potential to be one of the technologies that brings about this revolution. The manufacture of fertilizers and nano-fertilizers, which are added to the soil to improve its qualities and raise its fertility, as well as the spraying of it on plants, are two examples of how its applications have extended over a variety of fields, one of which is agriculture (Saleh, 2015).

The chemical and physical properties of Iraq's different soils each contribute to a unique level of fertility in the country's many ecosystems. In general, the soils of Iraq have a low percentage of organic matter as well as other nutrients like nitrogen and phosphorus (Ali et al., 2014). And that the increase in the proportion of lime and salinity in the soil of Iraq is a determining element for soil fertility as well as a determining factor in the fertilizer recommendations when crops are planted in it (Ali, 2012).

The majority of the fertilizers that are applied to plants are not suitable for use by the plants because of a number of causes including washing, volatilization, and sedimentation. Fertilizers are very necessary for the growth and development of plants. Since this is the case, it is imperative that new applications be developed with the assistance of nanotechnology and nanomaterial (DeRosa et al., 2010; Nair et al., 2010) in order to lessen the amount of nutrients that are lost during fertilization and to boost crop yields. , and nanotechnology plays a significant part in the agricultural industry because it facilitates the availability of a huge number of nanomaterials with multiple applications. These nanomaterials are put to use as fertilizers, which stimulate the growth of plants (Saleh, 2015). And that these materials contain all of the characteristics for use in agriculture such as effective concentration and solubility and with great effectiveness, as they are used in small quantities and avoid repeated addition to the plant, and that as a result, beneficial results are obtained from the first addition, which increases the efficiency of these fertilizers (Monreal et al., 2016). In addition, that these materials contain all of the characteristics for use in agriculture such as effective concentration and solubility and with great effectiveness, as they are used in small quantities

Nano-fertilizers are distinguished by their high solubility in addition to their high efficiency in penetrating plant tissues. Furthermore, they are utilized in small quantities and with high efficiency, and as a result, they play an important role in the resolution of a large number of challenges that are encountered in agriculture, including those posed by inorganic chemical fertilizers that are still in use. The purpose of using nanomaterials into agricultural methods is to enhance the productivity as well as the long-term viability of those systems (Jyothi and Hebsur, 2017). The purpose of this study is to determine the optimal level of chemical fertilizer to use in order to achieve optimal root growth, as well as the effect of spraying with nano fertilizer, the optimal concentration for the growth of cauliflower roots, and the optimal interaction between chemical fertilizer and nano fertilizer. In addition, the study aims to determine the optimal interaction between chemical fertilizer and nano fertilizer.

MATERIALS AND METHODS

An investigation into the impact that chemical fertilizer and the application of nano-fertilizer had on the development of cauliflower root systems was the purpose of the experiment that was carried out at the research station of the College of Agriculture at the University of Diyala. In order to have the area that was going to be used for the experiment ready, it was plowed and smoothed down before having a uniform level applied to it. The area that was being used for the experiment was partitioned into three sections, and each section had a terrace. After extending the main irrigation pipe at the far end of the experiment field to ensure an even distribution of water, the land was subdivided into experimental units. The length of an experimental unit is 2.5 meters, and its width is 2.4 meters, which results in an experimental unit that has an area of 6 square meters. The distance between each irrigation line and the edge of the terrace was 60 centimeters, and the distance between one irrigation pipe and another was 120 centimeters. There are two irrigation pipes in each Repeated. The seedlings were planted on both sides of the irrigation pipe, with a spacing of 30 centimeters (cm) between the planting line and the pipe on each side. There was also a distance of 50 centimeters (cm) between each seedling. At random and in a variety of spots across the field, soil samples ranging in depth from 0 to 30 centimeters were collected. After the sample was dried pneumatically, crushed, and put through a sieve with a diameter of 2 mm, a representative sample was taken from it and stored in plastic containers for the purpose of conducting some physical and chemical analyses prior to planting, as shown in (Table 1). The results of these analyses are included in the table. One of the private nurseries in the Buhraz region was used for the planting of cauliflower seedlings of the variety Solid Snow. After filling the cork dishes with peat moss to use as an agricultural medium, one seed was inserted in each slot of the plate, and further service operations were carried out on it until it was moved to the field.

Nano-fertilizer: The nano-fertilizer, which was purchased in the form of a powder at a nano-scale 80 nanometers 40 square meters / gram from the American corporation, is now ready for use (American Elements).

Table. 1. Some chemical and physical properties of the soil of the field in which the experiment was carried out.

<table>
<tr><th colspan="2">parameters</th><th>unit</th><th>value</th></tr>
<tr><td colspan="2">pH</td><td></td><td>7.3</td></tr>
<tr><td colspan="2">E.C (1.1)</td><td>Dsm^{-1}</td><td>8.06</td></tr>
<tr><td rowspan="3">Available nutrients</td><td>N</td><td>mg.kg-1</td><td>40.56</td></tr>
<tr><td>P</td><td>mg.kg-1</td><td>20.53</td></tr>
<tr><td>K</td><td>mg.kg-1</td><td>384.31</td></tr>
<tr><td colspan="2">O.M</td><td>gm.kg-1</td><td>0.828</td></tr>
<tr><td colspan="2">Caco3</td><td>gm.kg-1</td><td>321.1</td></tr>
<tr><td rowspan="3">Size of soil separation</td><td>sand</td><td>gm.kg-1</td><td>204.1</td></tr>
<tr><td>silt</td><td>gm.kg-1</td><td>567.7</td></tr>
<tr><td>clay</td><td>gm.kg-1</td><td>228.2</td></tr>
<tr><td colspan="2">Soil texture</td><td colspan="2">Silty loam</td></tr>
</table>

The drip irrigation system was used to carry out the process of irrigation. This system was comprised of the main units that are a source for the preparation of irrigation water (the basin), a pump with a horse power of 5.5 horses, and a filter. The basin was the primary unit used in the irrigation process (the filter). It transports water to pipes in the field that have a diameter of 0.016 meters and a length of 38 meters, and there are six lines that are spread out across the field. Within the context of a randomized complete block design (RCBD), a factorial experiment was conducted, and the experiment comprised a total of 12 treatments. These treatments were the combination of four different levels of chemical fertilizer, which were as follows: adding 0 (no fertilizer), adding 1/3 the recommended amount, adding 2/3 the recommended amount, and adding the recommended amount of chemical fertilizer. Adding 0 (no fertilizer) was the control group. It has a symbol (T0, T1, T2, T3), and it has three levels of nano fertilizer (calcium oxide) with concentrations of 0, 50, and 100 ppm. Additionally, it has a symbol (F0, F1, F3), and (table 2) displays the experiment's factorial coefficients. In order to do the analysis, the statistical package known as SAS was utilized, and Duncan's test was employed to determine whether or not the differences between the means were statistically significant.

After 10 days had passed since planting the seeds in the field, an application of the chemical fertilizer was made using the feeding method known as ground addition. The nano-fertilizer treatments, which consisted of calcium oxide, were applied to the seedlings by spraying them with it after (24) days had passed since they had been planted.

Table.2. components of the experiment

No	Treatment	Symbol
1	Without adding chemical fertilizer and without spraying nano fertilizer (control)	**T0F0**
2	Without adding chemical fertilizer and spraying 50 mg liter^{-1} of nano fertilizer	**T0F1**
3	Without adding chemical fertilizer and spraying 100 mg liter^{-1} of nano fertilizer	**T0F2**
4	Adding 1/3 of the recommended amount of chemical fertilizer and without spraying the nano fertilizer	**T1F0**
5	Add 1/3 of the recommended amount of chemical fertilizer and sprinkle 50 mg. l^{-1} of nano fertilizer	**T1F1**
6	Add 1/3 of the recommended amount of chemical fertilizer and sprinkle 100 mg. l^{-1} of nano fertilizer	**T1F2**
7	Adding 2/3 of the recommended amount of chemical fertilizer and without spraying the nano fertilizer	**T2F0**
8	Add 2/3 of the recommended amount of chemical fertilizer and spraying 50 mg. l^{-1} of nano fertilizer	**T2F1**
9	Add 2/3 of the recommended amount of chemical fertilizer and spraying 100 mg. l^{-1} of nano fertilizer	**T2F2**
10	Adding the recommended amount of chemical fertilizer and without spraying the nano fertilizer	**T3F0**
11	Add the recommended amount of chemical fertilizer and spraying 50 mg. l^{-1} of nano fertilizer	**T3F1**
12	Add the recommended amount of chemical fertilizer and spraying 100 mg.l $^{-1}$ of nano-fertilizer	**T3F2**

RESULTS

Plant height (cm)

Treatment T3, which received chemical fertilizer, recorded the greatest plant height of 83.11 centimeters, whereas treatment T0, which received no fertilizer, recorded the least plant height of 69.44 centimeters. These findings are presented in (Table 3), which demonstrates that the chemical fertilizer treatments significantly outperformed the control treatments in terms of plant height. In comparison to the height of the plant after receiving treatment F0, which was 75.66 cm, the height of the plant after receiving treatment F1 was 79.33 cm. When compared to treatment T0F0, which gave the shortest length of 62.33 cm, the T3F1 treatment recorded the maximum height of 85.33 cm; in contrast, treatment T0F0 gave the shortest length of 62.33 cm. The results in the same table reveal that there is a considerable superiority of the overlap.

Table. 3. Effect of chemical fertilizer, nano fertilizer and interference on plant height (cm).

Nano fertilizer treatments	Chemical fertilizer treatments				
	T0	T1	T2	T3	nano fertilizer averages
F0	62.33 f	76.00 cde	81.33 abc	83.00 ab	75.66 B
F1	73.66. ed	78.00 bcd	80.33 abc	85.33 a	79.33 A
F2	72.33 e	77.00 cde	77.66 bcd	81.00 abc	77.00 AB
Chemical Fertilizer averages	69.44 D	77.00 C	79.77 B	83.11 A	

Means of coefficients with similar letters do not differ significantly among themselves at the 5% probability level according to Duncan's polynomial test.

Uppercase letters indicate a comparison of the effects of the principal factors, while lowercase letters indicate a comparison of overlap averages.

Leaf area (dm2)

It is clear from looking at (Table 4) that the treatments with chemical fertilizer are significantly superior in terms of their effectiveness in the leaf region. When compared to treatment T0, which recorded the lowest leaf area at a total of 146.92 cm2, treatment T3 recorded the maximum area, which amounted to 288.04 cm2 in total. Spraying with nano-fertilizer led to a significant improvement, as the F1 treatment recorded the highest area Paper amounted to 249.59 dm2 compared to the F0 treatment, which recorded the lowest area of 222.22 dm2. This demonstrated that the F1 treatment had a significant advantage over the F0 treatment. The findings presented in the same table demonstrate that there is a considerable degree of overlap. When compared to the comparison treatment, which recorded the lowest leaf area of 115.10 dm2, the two treatments T3F2 and T3F1 recorded the largest leaf area, with 293.33 and 291.31 dm2 respectively for the highest and lowest values, respectively.

Table. 4. Effect of chemical fertilizer, nano fertilizer and interference on leaf area (dm2)

Nano fertilizer treatments	Chemical fertilizer treatments				
	T0	T1	T2	T3	nano fertilizer averages
F0	115.10 d	241.45 ab	252.87 ab	279.47 ab	222.22 B
F1	166.94 c	253.91 ab	286.20 ab	291.31 a	249.59 A
F2	158.72	235.24 b	244.23 ab	293.33 a	232.88 AB
Chemical Fertilizer averages	146.92 C	243.53 B	261.10 B	288.04 A	

Means of coefficients with similar letters do not differ significantly among themselves at the 5% probability level according to Duncan's polynomial test.

Uppercase letters indicate a comparison of the effects of the principal factors, while lowercase letters indicate a comparison of overlap averages.

Number of leaves (one leaf per plant)

According to the findings presented in (Table 5), treatments including chemical fertilizers have a discernible advantage when it comes to the total number of leaves produced. The maximum number of leaves was recorded by Treatment T3, which totaled 24.11 leaves, in contrast to the comparison treatment, which recorded the lowest number of leaves, which totaled 15.33 leaves. Treatment T3 recorded the highest number of leaves. The application of nano-fertilizer as a spray had no discernible effect. Significant differences were found between the treatments. The findings presented in the same table demonstrate that there is a statistically significant advantage conferred by the interaction. This is demonstrated by the fact that the T3F1 treatment recorded the highest number of leaves, which reached a total of 25.66 leaves, in contrast to the comparison treatment, which gave the smallest number of leaves, which totaled 13.33 leaves. This indicates that the interaction is significantly more advantageous.

Table. 5. The effect of chemical fertilizer and nano fertilizer and the interaction between them on the number of leaves (a leaf of a plant).

Nano fertilizer treatments	Chemical fertilizer treatments				
	T0	T1	T2	T3	nano fertilizer averages
F0	13.33 d	19.33 bc	20.66 abc	23.00 ab	19.08 A
F1	16.33 cd	20.33 abc	22.33 ab	25.66 a	21.16 A

F2	16.33 cd	19.66 bc	20.00 abc	23.66 ab	19.91 A
Chemical Fertilizer averages	15.33 C	19.77 B	21.00 B	24.11 A	

Means of coefficients with similar letters do not differ significantly among themselves at the 5% probability level according to Duncan's polynomial test.

Uppercase letters indicate a comparison of the effects of the principal factors, while lowercase letters indicate a comparison of overlap averages.

root weight (gm plant)

The findings presented in (Table 6) indicate that the chemical fertilizer treatments significantly outperformed the control group in terms of root weight. Specifically, treatment T3 recorded the highest weight of 108.44 g when compared to treatment T0, which gave the plants the least amount of weight, which was 69.77 g. When compared to treatment F0, which recorded the lowest weight of 79.91 gm of plants, treatment F1 recorded the maximum weight of 89.75 gm for the plants. The findings are presented in the same table, and they demonstrate that the interaction had a substantial effect. When compared to treatment T0F0, which resulted in the lowest weight of 64.66 gm of plants, the treatment T3F1 produced the maximum weight, which was reported as 116.00 gm.

Table.6. Effect of chemical fertilizer and nano fertilizer and the interaction between them on root weight (gm of plants)

Nano fertilizer treatments	Chemical fertilizer treatments				
	T0	T1	T2	T3	nano fertilizer averages
F0	64.66 f	73.66 ef	81.00 de	100.33 b	79.91 B
F1	73.66 ef	78.66 de	90.66 c	116.00 a	89.75 A
F2	71.00	73.33 ef	84.00 cd	109.00 ab	84.33 B
Chemical Fertilizer averages	69.77 D	75.22 C	85.22 B	108.44 A	

Means of coefficients with similar letters do not differ significantly among themselves at the 5% probability level according to Duncan's polynomial test.

Uppercase letters indicate a comparison of the effects of the principal factors, while lowercase letters indicate a comparison of overlap averages.

root diameter (mm).

The findings presented in (Table 7) suggest that the chemical fertilization treatments had a considerable impact on the root diameter. T3 produced the largest root diameter of 6.40 millimeters, in contrast to T0, which produced the smallest root diameter of 4.23 millimeters.

It has come to our attention that there are no discernible differences between the treatments with regard to the effect that spraying treatments with nano-fertilizer has. The findings may be shown in the same table, and they demonstrate that the interference had a considerable effect. When compared to T0F0, which delivered the smallest diameter of 3.75 mm, the treatment (T3F) recorded the largest diameter, which was 6.94 millimeters.

Table. 7. Effect of chemical fertilizer and nano fertilizer and the interaction between them on root diameter (mm).

Nano fertilizer treatments	Chemical fertilizer treatments				
	T0	T1	T2	T3	nano fertilizer averages
F0	3.75 e	4.80 cde	5.38 bcd	5.84 abc	4.94 A
F1	4.63 cde	4.83 cde	5.63 abcd	6.94 a	5.51 A
F2	4.31 de	5.09 bcde	5.21 bcde	6.43 ab	5.26 A
Chemical Fertilizer averages	4.23 C	4.91 BC	5.41 B	6.40 A	

Means of coefficients with similar letters do not differ significantly among themselves at the 5% probability level according to Duncan's polynomial test.

Uppercase letters indicate a comparison of the effects of the principal factors, while lowercase letters indicate a comparison of overlap averages.

root length (cm)

The findings, which can be shown in (Table 8), indicate that the chemical fertilization treatments had a notable impact on the root length. When compared to treatment T0, which yielded the shortest length of 16.11 cm, the length that was reported with treatment T3 was the greatest at 23.77 cm. As for the effect of spraying treatments with nano fertilizer, we notice a significant superiority of the two treatments F2 and F1, which gave the highest length of -21.08 and 21.00 cm, respectively, in comparison to the F0 treatment, which recorded the lowest length of 41 19. cm. This is in contrast to the F0 treatment, which gave the longest length of -21.08 cm. The findings may be shown in the same table, and they demonstrate that the interference had a considerable effect. When compared to treatment T0F0, which recorded the shortest length of 13.66 centimeters, the two treatments T3F1 and T3F0 recorded the longest lengths of 24.33 and 24.00 centimeters, respectively.

Table .8. Effect of chemical fertilizer and nano fertilizer and the interaction between them on root length (cm).

Nano fertilizer treatments	Chemical fertilizer treatments				
	T0	T1	T2	T3	nano fertilizer averages
F0	13.66 f	19.33 cd	20.66 bcd	24.00 a	19.41 B

F1	16.00 ef	21.33 abcd	22.33 abc	24.33 a	21.00 A
F2	18.66 de	20.66 bcd	22.00 abc	23.00 ab	21.08 A
Chemical Fertilizer averages	16.11 C	20.44 B	21.66 B	23.77 A	

Means of coefficients with similar letters do not differ significantly among themselves at the 5% probability level according to Duncan's polynomial test.

Uppercase letters indicate a comparison of the effects of the principal factors, while lowercase letters indicate a comparison of overlap averages.

DISCUSSION

It is evident from the tables that there is a significant effect of chemical fertilizer for all growth, root, and vegetative characteristics, and the reason may be due to the fact that it contains essential elements of the plant, which have an important role in the vital activities that take place inside the plant, in addition to the role of nitrogen and phosphorous, which are included in the synthesis of nucleic acids, DNA, and RNA. This effect of chemical fertilizer is clear from the tables. The function of proteins in the process of cell division. The role of the element phosphorous, which works to strengthen the root group and contributes to the vital processes of plant growth, especially the storage of energy and its conversion to ATP and the formation of enzymatic chaperones, may also be a factor in this phenomenon. Phosphorous works to strengthen the root group by working to strengthen the root group. Phosphorous also promotes early plant maturity and healthy root development in the plant (Abu Dahi and Younis, 1988). Potassium plays an important part not only in the activation of enzymes and the production of proteins, but also in the regulation of other processes, such as the absorption of water and the opening and closing of stomata. These processes improve the plant's ability to make effective use of water and aid in the movement of nutrients from the roots to the rest of the plant's parts. Additionally, it is responsible for the movement of created materials from the top regions of the structure. It also promotes cell division and contributes to the thickening of the walls, which results in a reduction in illness and is represented by the leaves all the way down to the roots (Al-Sahhaf, 1989) The availability of elements around the root zone led to the construction of an efficient root system, which in turn led to the absorption of nutrients and water in the required quantities. This demonstrates that the traits that were studied had a positive effect, as they led to the availability of elements around the root zone. These findings are in agreement with those found by Al-Zuhairi (2016) as well as those found by Chand et al (2017). It has also been shown that the nano-fertilizer has a discernible impact on the vegetative and root features that were under investigation. It's probable that this is because of the nano-unusual fertilizer's features, which are a result of its diminutive size. These properties made it feasible for the plant to absorb the fertilizer in an effective manner. Additionally, the increase in its surface area increased the absorption surface, which led to an increase in the amount of substance that was taken up directly by the plant cells. (Sabir et al., 2014). Also, the large surface area that is characteristic of nano-fertilizers contributes to increasing the activity of enzymes directed toward increasing the speed of chemical and biological reactions that take place within the plant cell. This increases the synthesis of amino acids and nucleic acids, in addition to the role that nanomaterials play in inhibiting the formation of free radicals that appear when the plant is subjected to stress. This results in fewer oxidation processes, which in turn stimulates the plant's vegetative development and slows down its aging, all of which are a direct result of the lack of irrigation water (Tripathi et al., 2018) and (Ahmed, et al., 2019)

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