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The Effect of Spraying Calcium Nano Fertilizer and Humic Acid on the Growth and Yield of Cauliflower Crop in Calcareous Soils

Hanan Abdullah Ali[1*], Sadik Kadhim Taaban[2], Walaa Salah Challoob[3]
[1]Department of microbiology, college of science, Al-Karkh University of science, Iraq
[2]Corporation of Research and Industrial Development, Ministry of industry and minerals, Iraq
[3]College of science, Al-Karkh University of science, Iraq

ABSTRACT: This research aims to demonstrate the effect of using nano-fertilizer (calcium oxide) on the growth of cauliflower at concentrations (0, 100, 200) ppm and humic acid in concentrations (0, 2, 4) ml .l-1 and its effect in growth and yield of cauliflower crop (plant height, disc weight, and total yield) also (diameter of disc, leaf area, fresh leaf weight) and study this effects in calcareous conditions in calcareous soil. The results showed the superiority of the treatment (H2+Ca200) in terms of its impact togather on the studied treatments, as it achieved the best results, which reached 47.18 cm, 0.97 kg, 40.95 T.ha-1, 24.60 cm, 284.33cm2, 0.99 kg respectively, There were significant differences between the studied treatments, and the experiment showed the possibility of using a combination of foliar fertilization of both organic humic acid and nano-calcium fertilizer in achieving the best growth and production rates for cauliflower plant yield.

KEYWORDS: calcium nano fertilizer, humic acid, Calcareous soil, cauliflower crop, foliar application.

INTRODUCTION

The soils in the Middle East and North Africa are from the Calcareous soil type, which suffers from many limitations that make the use of fertilizers and nutrients added to the crops have low effect or efficiency, due to factors such as the Ph and the presence of carbon minerals in the soil and other factors, which leads to their transformation to unavailable forms for absorption by the plant (Taalab et al., 2019). As a result of the influence of these factors, nutrients, especially the major elements are exposed to volatilization and loss processes through washing, sedimentation, and retention, and the same applies to minor elements, exception of molybdenum (Havlin et al., 2013). find solutions to these obstacles and limitations, there are to nanotechnology, which is considered one of the promising, modern, and advanced technologies by reducing the parts to sizes equal to 1 to a billion meters, as the materials whose particle size is equal to (1-100) nanometers are considered nanomaterials (Li et al.,2022). These properties of nanomaterials have made their use in the fertilizer industry a stimulating and beneficial matter for plants through their role in improving the efficiency of fertilizers, as they are more soluble and faster to be represented inside plant tissues (Dimkpa and Bindraban, 2017). Also, these fertilizers, in addition to their effectiveness, are considered environmentally friendly (Liu and Lal,2015). The effective and efficient use of these fertilizers has made it possible to achieve higher crop productivity by improving soil fertility as well as crop quality, as these fertilizers, through the technologies they possess, including their packaging in capsules, work to control the release of elements and nutrients to the plant's surroundings for the longest possible period, which enables the plant to benefit from them in a ready form as well as ensuring that they are not lost through washing processes with irrigation water to depths far in the soil, out of the reach of plants (DeRosa et al., 2010).

The concept behind nano-fertilizers is to reduce particle size to the nano level, increasing the surface area and promoting more efficient chemical reactions and absorption by plants (Ditta and Arshad, 2016). Studies have shown that using nano-fertilizers can reduce the amount of traditional fertilizers needed by 20-35% (Tripathi et al., 2018). Cauliflower, a winter vegetable from the cruciferous family, is rich in nutrients such as phosphorus, potassium, magnesium, iron, vitamins A, B1, B2, proteins, amino acids, and fibers, which aid digestion and offer various medical and therapeutic benefits (Al-Muhamadi and Al-Mashaal,1989; Metadi et al.,2011) . Humic acid, an organic fertilizer derived from decomposed organic materials, contains essential nutrients that enhance plant growth and improve nutrient absorption by roots (Selladurai and Purakayastha, 2016) . This research aims to highlight the benefits of using organic and nano fertilizers to enhance the growth and yield of cauliflower plants in calcareous Iraqi soil conditions.

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THE MATERIALS AND METHODS

During the 2022 agricultural season, a field experiment was conducted to grow cauliflower in a silty clay-mixed soil. The experiment involved the use of liquid humic organic fertilizer and nano calcium fertilizer. The field was prepared for cultivation by plowing, smoothing, and leveling. The field was divided into sectors, with each experimental unit measuring 3 meters in length and 3 meters in width, resulting in a total area of 9 square meters. The seedlings were planted in rows with a distance of 50 cm between each row and 30 cm between each seedling in the same row, leaving a distance of 60 cm between replicates. The crop was sprayed twice with liquid organic fertilizer and nanocalcium, with the first spraying occurring twenty days after planting and the second two weeks after the first spraying. In the control treatments, the crop was sprayed with distilled water only. The spraying process was conducted twice, the date first spraying was in 15 days after planting and the second was 45 days after planting, two weeks after the first spraying for both organic and nano fertilizers. Soil fertilizer was added in the recommended quantities for nitrogen, phosphorus, and potassium. Specifically, nitrogen fertilizer was added in the form of urea with a concentration of N46%, phosphate fertilizer was added in the form of triple superphosphate (P20%), and potassium fertilizer was added in the form of potassium sulfate (41% K). Weeding was also added to remove harmful weeds.

Before planting random samples were taken from the field soil at a depth of 0-30 cm before planting, and then some chemical and physical properties of the soil were analyzed as shown in the table (Table 1). After the plants were harvested at the end of the season, samples were taken from the replicates of each treatment, and their characteristics were studied. The studied characteristics were plant height, number of leaves per plant, disc diameter, disc weight, leaf area, fresh leaf weight, and total yield. The experiment included 9 treatments by matching three levels of nano fertilizer (zero, 100, 200) mg. ml and liquid organic fertilizer at concentrations (zero, 2, 4) ml. L^{-1}. They were symbolized as H0, H1, and H2. Notably, Liquid organic fertilizer was obtained from local markets with the specifications shown in the table (2).

The liquid nano fertilizer was obtained from the Indian Organic Farm Company. The experimental coefficients were distributed according to a complete randomized block design within a factorial experiment. The statistical analysis was conducted using the SPSS program, and the least significant difference for the coefficients was chosen within the 5%.

Table (1) Physical and chemical characteristics of the soil before planting

parameter	value	unit
Ph	7.7	
EC	3.68	$ds.m^{-1}$
O.M	9.42	$gm.kg^{-1}$
Ca^{+2}	11.20	$mmol.kg^{-1}$
Mg^{+2}	10.7	$mmol.kg^{-1}$
Na^{+2}	27.70	$mmol.kg^{-1}$
K^{+}	0.43	$mmol.kg^{-1}$
SO_4	19.60	$mmol.kg^{-1}$
CO_3	nill	
HCO_3	0.43	$mol.kg^{-1}$
Cl^{-1}	32.48	$mmol.kg^{-1}$
N	30.68	$mg.kg^{-1}$
P	47.13	$mg.kg^{-1}$
K	380.10	$mg.kg^{-1}$
Silt	540	%
Loam	320	%
Clay	140	%
Bulk density	1.33	$Mg.m^{-3}$

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Table (2) chemical and physical properties of humic acid used in the experiment

Traits	Units	Components
Ec	d.S-1	1.93
pH	-	5.4
C	%	42.20
N	%	2.53
C: N	%	15
P	%	0.670
K	%	2. 94
Ca	%	2.98
Mg	%	0.870
Na	%	0.650
Fe	%	0.530
Zn	%	0.038
Cu	%	0.042
Mn	%	0.006
Humidity	%	32

THE RESULTS AND DISCUSSION

Plant height:

The results in Table (3) demonstrated a significant effect of the organic fertilizer added as a spray on the leaves in the treatment of measuring plant height, as the concentration of 4 ml. L-1 achieved the highest height rate of 38.63 cm and an increase of 24.12% over the comparison treatment in which the plant height reached 35.4 cm. The results in Table (3) also showed that the treatment of adding nano fertilizer at a concentration of 200 mg. L-1 was significantly superior to the rest of the treatments, achieving a height rate of 41.63 cm and a significant increase over the comparison treatment of 16.64%, which achieved the lowest height rate of 35.69 cm. The interaction between adding calcium nano-fertilizer with organic humic acid fertilizer had significant effects on the plant height trait, as the interaction treatment achieved by adding organic fertilizer in concentration with nano-fertilizer in concentration in achieving the highest height rate of 47.18 cm, achieving an increase rate of 41.68% over the comparison treatment that included spraying with water only, at which the plant height rate reached 33.30 cm.

Table (3) Effect of spraying with organic humic acid and nano calcium fertilizer on plant height (cm)

Treatments	Ca0	Ca100	Ca200	The Mean of humic acid
H0	33.30 a	35.82 b	37.08 c	35.4 f
H1	35.16 b	38.78 d	40.65 e	38.19 g
H2	38.63 c	43.94 h	47.18 l	43.25 i
The mean of nano calcium	35.69 A	39.51 B	41.63 C	38.94

Mean values with different letters indicate significant differences according to Duncan's test at a significance level of 0.05.

Disc weight

The results presented in Table 4 indicate that the addition of organic fertilizer to the cauliflower plants had a significant effect on disc weight. Specifically, the H2 concentration resulted in the highest average disc weight of 0.75 kg, representing a substantial

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increase of 78.31% compared to the control treatment, which had an average disc weight of 0.53 kg. Additionally, the application of nano calcium fertilizer at a concentration of 200 mg led to a highest average disc weight of 0.82 kg, representing a 60.78% increase compared to the control treatment, which had an average disc weight of 0.51 kg. Furthermore, the interaction between organic fertilizer and foliar spraying had a significant effect on plant yield, with the treatment H2Ca200 resulting in the highest average disc weight of 0.97 kg, representing a 115.55% increase over the control treatment.

Table (4) Effect of spraying with organic humic acid and nano calcium fertilizer on Disc weight (kg)

Treatments	Ca0	Ca100	Ca200	The mean of humic acid
H0	0.45 a	0.50 d	0.66 g	0.53 A
H1	0.52 b	0.62 e	0.85 h	0.66 B
H2	0.57 c	0.73 f	0.97 i	0.75 C
The mean of nano calcium	0.51 A	0.61 B	0.82 C	

Mean values with different letters indicate significant differences according to Duncan's test at a significance level of 0.05.

Disc Diameter

Table No. 5 presents the effect of different treatments on the average disc diameter of the plant. The results indicate that there is a significant effect. When organic acid was used, treatment H2 showed the best results with an average disc diameter of 21.80 cm. In contrast, the treatment without organic acid (control treatment) had the lowest average disc diameter, measuring 15.98 cm. This represents a substantial increase of 36.42% between the highest and the control treatments.

Regarding the effect of nano fertilizer, the use of 200 ml concentration from nano calcium resulted in the highest average disc diameter of 21.90 cm, showing a significant increase of 31.92% compared to the control treatment .also to the combined effect of organic and nano fertilizer was also analyzed. The treatment H2Ca200 displayed the highest average disc diameter at 24.60 cm, marking a significant increase of 75.46% compared to the control treatment.

Table (5) Effect of spraying with organic humic acid and nano calcium fertilizer on Disc Diameter (cm).

Treatments	Ca0	Ca100	Ca200	Mean of humic acid
H0	14.02 a	15.24 d	18.68 g	15.98 A
H1	16.45 b	18.53 e	22.44 h	19.14 B
H2	19.34 c	21.48 f	24.60 i	21.80 C
The mean of nano calcium	16.60 A	18.41 B	21.90 C	

Mean values with different letters indicate significant differences according to Duncan's test at a significance level of 0.05.

Fresh leaf weight

The results in Table (6) showed significant differences between the different treatments in the effects of added fertilizers on the yield, as there was a significant difference when adding liquid organic fertilizer, as the concentration of 4 ml. L achieved the highest rates in fresh leaf weight, as the highest rate of this effect reached 0.89 kg and a significant increase of 50.84%, while the treatment of adding nano calcium fertilizer at a concentration of 200 mg. ml achieved the highest rate, which reached 0.88 kg and a significant increase over the comparison treatment of 31.92%. The interaction between nano and organic fertilizers achieved significant effects

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on the average fresh leaf weight of the crop, as the treatment of adding organic fertilizer at a concentration of 4 ml and nano fertilizer at a concentration of 200 mg achieved the highest fresh leaf weight, which reached 0.99 kg and a significant increase over the comparison treatment, which reached 53.54%.

Table (6) Effect of spraying with organic humic acid and nano calcium fertilizer on Fresh leaf weight (kg) .

Treatments	Ca0	Ca100	Ca200	The mean of humic acid
H0	0.46 a	0.57 d	0.75 g	0.59 A
H1	0.68 b	0.74 e	0.91 h	0.77 B
H2	0.79 c	0.89 f	0.99 k	0.89 C
The mean of nano calcium	0.64 A	0.73 B	0.88 C	

Mean values with different letters indicate significant differences according to Duncan's test at a significance level of 0.05

Leaf area (cm^2):

Adding fertilizers in the experiment had significant effects on the leaf area rates of the crop, as adding liquid organic fertilizer sprayed on the leaves of the cauliflower crop achieved significant effects as in Table (7), as adding organic fertilizer at a concentration of 4 ml/liter led to the highest rate in the leaf area of the crop, which reached 268.80 cm2 at this concentration, with a significant increase over the comparison treatment, which achieved a leaf area of 146.32, as the increase rate was about 83.70%. Adding Nano calcium fertilizer had a significant effect when added at a concentration of 200 mg/liter, reaching 13.11%. The combined effect of both organic and nano fertilizers was significant, as the H2Ca200 combined treatment achieved the highest rate in the leaf area of the crop, which reached 284.33 cm2, with a significant increase over the comparison treatment of 51.34%.

Table (7) Effect of spraying with organic humic acid and nano calcium fertilizer on Leaf area (cm^2).

Treatments	Ca0	Ca100	Ca200	The mean of humic acid
H0	138.34 a	147.64 d	153.00 g	146.32 A
H1	224.27 b	248.73 e	260.15 h	244.38 B
H2	253.84 c	268.24 f	284.33 l	268.80 C
The mean of nano calcium	205.48 A	221.53 B	232.49 C	

Mean values with different letters indicate significant differences according to Duncan's test at a significance level of 0.05.

Total yield:

The results in Table (8) showed the significant effects of using the experimental treatments on the total yield of the cabbage plant, as the organic fertilizer added by spraying on the leaves at concentration H2 achieved the highest rate of total yield, which reached 32.92 tons per hectare, with a significant increase over the control treatment of 74.17%. As for adding nano fertilizer, the treatment uses a concentration of 200 ml. L-1 achieved the highest rate in total yield, which reached 33.17 t. ha-1 . with a significant increase over the control treatment, which achieved 20.82 t. ha -1, which reached 59.31%. As for the effect of the interaction between organic and nano fertilizer, the effect was significant, and the treatment resulting from adding organic fertilizer at concentration 4ml.l- and

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nano fertilizer at concentration 200ppm achieved the highest rate of total yield, which reached 40.95 tons. The hectare, with a significant increase over the comparison treatment, which amounted to 55.40%.

Table (8) Effect of spraying with organic humic acid and nano calcium fertilizer on total yield (Tons).

Treatments	Ca0	Ca100	Ca200	The mean of humic acid
H0	15.28 a	18.68 d	22.74 g	18.9 A
H1	20.84 b	24.70 e	35.82 h	27.12 B
H2	26.35 c	31.48 f	40.95 i	32.92 C
The mean of nano calcium	20.82 A	24.95 B	33.17 C	

Mean values with different letters indicate significant differences according to Duncan's test at a significance level of 0.05.

The presence of lime in Iraqi soils is considered a hindering and limiting factor for the positive effect of fertilizers added to the soil to various crops, including vegetable crops, as it causes a reduction in the quantities ready and available to the plant, especially in the early stages of plant growth when the plant's need for nutrients is great in order to complete its physiological processes. The method of adding by spraying is considered one of the positive solutions to address the problem of element deficiency in the soil and lack of readiness, as it provides the plant with its needs of elements in a balanced manner with the released elements added to the plant through the soil. Organic fertilizers play an effective role in improving and increasing the positive characteristics of growth and yield of cauliflower, as these fertilizers, through the micro and macro elements they contain, work to increase and raise the efficiency of the photosynthesis and respiration process and in the process of building protoplasm, as they enter into the composition of RNA and DNA nucleic acids necessary for cell division, which leads to increasing the elongation process of the stems and thus increasing the height of the plant as well as increasing the leaf area of the plant and other vegetative growth characteristics, in addition to the total yield and quality of plants, and this is consistent with what was indicated by (Rameshaiah et al, 2015) and (Tawfiq & Al-Sahaf, 2017).

The use of calcium nano-fertilizers has had a positive and significant impact on the growth and yield of cauliflower. These nano-fertilizers are known for their high solubility and ability to penetrate plant tissues and metabolize within the plant. They contain essential nutrients crucial for the biological structure of the plant, which enhances the efficiency of the photosynthesis process and increases the absorption of elements. This, in turn, prolongs the life of the leaves, delays aging, and increases the production of materials in the leaves, ultimately improving the quality of fruits and seeds. Furthermore, the use of nano elements has been found to stimulate the elongation and division of green cells, thereby increasing the number of divisions in the areas of leaf formation. This aligns with findings from previous studies (Manea, 2017; Singh et al., 2017; El-Hafez, 2017).

CONCLUSIONS

Vegetables crops like cauliflower are economically important, but they suffer when grown in calcareous soils due to a lack of nutrients. This affects the quality and production of these crops. To resolve this problem, adding organic fertilizers rich in micro and macronutrients, as well as nano fertilizers, has aided in compensating for the deficiency in these elements. This has led to an increase in the representation of nutrients within plant tissues, resulting in positive effects on the quality and productivity of the crop. Additionally, applying these fertilizers as sprays on the leaves has increased the efficiency of nutrient absorption.

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