

# Impact of organic fertilizer in different sowing dates on growth , yield and and hormonal containts of cabbage *Brassica oleracea var capitata*

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## Abstract

A study included 12 treatments that was carried out outside the University of Mosul's College of Agriculture and Forestry; both are located in Mosul in the Republic of Iraq using a Factorial Experiment. Within. Split-Plot design within the context of a Randomized. Complete. Block. Design. (RCBD). The study included the effects of three factors: two sowing dates (27/8/2025 and 27/9/2025), two methods of application (adding to soil and foliar spraying) and three concentrations of the liquid organic fertilizer TECAMIN MAX (0, 2.5, and 5 ml/l). Each treatment was repeated three times in Copenhagen cabbage plants cultivar. The results of the statistical analysis utilizing the Duncan's multiple-range test with a significance level of 5% showed the following: Plants sowing in the first date significantly outperformed compared to plants sowing in the second date in relation to the height of the plant, the number of rolled leaves, the marketable head weight rate, and the marketable yield per unit area. When compared to the spraying approach, the addition to the soil method resulted in a considerable increase in the marketable of head weight as well as the marketable yield per unit area. Plants that were given either dosage of organic fertilizer had a substantial effect on all of the characteristics that were investigated, with the exception of the 2.5 ml dose. Leaves content of growth hormones GA3 and IAA increased significantly when plants were grown on the first date compared to plants grown on the second date. The use of both concentrations of 2.5 and 5 ml per liter of organic fertilizer TECAMIN TEXT resulted in a significant increase of these two hormones in the leaves compared to the control treatment.

**Keywords:** Copenhagen, GA3, IAA, Rolled, Tikkamin Max.

## Introduction

Among the well-known names for the cabbage plant in some Arab countries are both "al-malfouf" and "al-karnab" (cabbage and kale). In English, it is known as "Cabbage," and its scientific name is *Brassica oleracea var capitata*. The cabbage plant belongs to a group of cruciferous vegetables known as the Cole Crops, which include along with cabbage, cauliflower, broccoli, collard greens, mustard greens, Chinese cabbage, kohlrabi, and Brussels sprouts. It is believed that the cultivated cabbage we have today originated from a wild variety that did not have heads and has been growing for thousands of years in Turkey and the Eastern Mediterranean region. Cabbage has been cultivated for over 4,500 years and was known to the ancient Egyptians, Greeks, and Romans. It is said to have been found in Roman tombs. Cabbage is considered a vegetable rich in niacin (0.3 mg per 100 g) and is also rich in vitamin C (47 mg per

100 g) and has a moderate calcium content (49 mg per 100 g) (Hassan, 2012). Cabbage has medicinal uses as well. It reduces the risk of gastric and duodenal ulcers and lowers blood sugar and cholesterol levels in patients (Talalay and Fahey, 2001). Studies have shown that vegetables belonging to the cruciferous family contain a compound called isothiocyanate, which has shown high effectiveness against bladder cancer."

The planting date for any crop is determined by the prevailing conditions in the production area, including light and temperature. Agricultural methods also play a role in manipulating light and temperature, as well as the use of modern adding to the soil techniques and the selection of varieties (hybrids or pure, early or late) to adjust the planting date for any crop. Therefore, we find that the planting date for a particular crop varies from one region to another worldwide, as well as within the same country (Ibraheem, 2007).

In a study conducted by Wszelaki and Kleinhenz (2003), in Ohio, USA, to examine the effect of three planting dates: May 1st, June 1st, and July 1st, for the cabbage varieties DPX and Super Elite, it was observed that planting on June 1st resulted in a significant increase in plant height, fresh and dry weight, and most of the studied traits. In a study conducted by Tendaj and Sawicki (2012), to examine the effect of two sowing dates: April 19th, and May 8th of six Market cabbage cultivars, it was observed that early sowing date led to a substantial increase in the number of leaves and most of the studied traits compared to the subsequent transplanting dates. Ullah *et al.*, (2013) found in their study conducted on the Autumn Queen cabbage variety that the leaves number, plant height, head weight, yield, and head circumference significantly decreased when sowing on the later date of November 21st compared to the first date of November 1st and the second date of August 14th. In a study by Liu *et al.*, (2022), regarding the effect of three planting dates: September 15th, September 30th, and October 15th, for red cabbage plants, it was observed that traits such as the leaves number in the marketable head, length and circumference of the head, and total and marketable yield significantly increased when sowing on the second date compared to the other two dates." In a study conducted by Yadav *et al.*, (2022), to examine the effect of three sowing dates: November 5th, November 15th and November 25th for cabbage, it was observed that early sowing date led to a substantial increase in the number of leaves and head weight compared to the subsequent transplanting dates. Sidoine and Xavier (2022), in study regarding the effect of three sowing dates: December 15th and December 30th, for cabbage plants, it was observed that traits such as the leaves number in the marketable head, length and circumference of the head, and total and marketable yield significantly increased when sowing on the second date compared to the other two dates.

"Numerous studies have emphasized the importance of organic fertilizers, whether derived from animal sources, wild plants, or marine plant extracts, in stimulating plant growth and improving quantitative, qualitative, and storage traits in vegetable crops (Ibraheem, 2012). They are beneficial in achieving the best condition for plants and extending their growth period. Additionally, organic fertilizers play a vital role in reducing water consumption and enhancing the plant's efficiency in utilizing soil moisture content, also promote root growth and improve their ability to absorb nutrients. Moreover, many of these organic fertilizers,

especially organic amendments, have the ability to inhibit the growth of some harmful microorganisms and fungi, thereby enhancing plant growth, productivity, and quality (Odell, 2009 and Abd Alla, 2015).

Farjana *et al.*, (2019), found that when adding the organic fertilizer (Vermicompost and FYM) to the field planted with cabbage plants at a rate of 5 kg per square meter a substantial increase in the number of leaves, plant height, fresh and dry weight of plants in addition to a significant increase in the average head weight and marketable head yield. The results reached by Iddrisu (2021), demonstrated that there was a substantial increase in the number of leaves of the cabbage plant, fresh and dry weight of the heads and the unit area of the marketable heads when using the organic fertilizer (Cypermethrin) at a rate of 30 liters per hectare sprayed on vegetative growth. Characteristics related to growth and yield represented by the leaves number, plant height, leaves area, weight of the marketable head, diameter of the head, and the % of dry matter in the leaves of cabbage plants increased significantly when using the organic fertilizer (Poultry Manure) at a rate of 12 tons per hectare in the study carried out by (Debrah *et al.*, 2021). As for Shamad *et al.*, (2023), in their study on cabbage plants, when using organic fertilization of two mixtures of Vermicompost and FYM at a rate of 15 tons per hectare they found a significant increase in the characteristics related to growth, yield, and quality, represented by the leaves number, plant height, leaf area, marketable head weight, and head diameter.

"Various methods have been employed to apply organic fertilizers in commercial production fields to demonstrate the role of these fertilizers in the growth and productivity of vegetable plants. Some researchers have relied on the foliar spray method for applying organic fertilizers. In a study conducted by Saadoon and Abd Ghali (2014), foliar spray method using palm leaf extract as an organic fertilizer at concentrations of 25, 50, and 75 ml/liter resulted in a significant increase in the yield of cabbage plants. Mohammed & Manea (2018) Al-Chalabi *et al.*, (2023), achieved a significant increase in the height of cabbage plants and the yield of cabbage heads by using foliar spray application of the liquid organic fertilizer "Reef Amirich" in combination with the red cabbage variety. On the other hand, other studies have focused on soil application methods to examine the effects of organic fertilizers. Chaudhary *et al.*, (2018), used cow dung and vermicompost as organic fertilizers in cabbage fields, and the addition of nitrogen fertilizer along with these organic fertilizers led to significant increases in most of the

growth and yield traits of cabbage plants. Furthermore, some researchers have adopted a combination of the previous methods to enhance the growth and yield traits in vegetable production fields. Examples include (Ibraheem, 2012 and Abdul-wahid, 2020), who utilized integrated approaches combining foliar spray and soil application methods to improve the growth and yield characteristics in vegetable production fields."

"The objective of this study was to enhance the growth and yield of cabbage plants under the conditions of Nineveh Governorate. This was achieved by using the liquid organic fertilizer "Tekamin Max" derived from plant sources. Additionally, the study aimed to find the optimal planting date for cabbage plants, identify the best method of fertilizer application that cabbage plants respond to, and determine the best interaction of planting dates, application methods, and concentrations of the organic fertilizer under investigation.

### Materials and Methods

A study conducted in the context of a scientific field that belonging to a portion of the Agriculture and Forestry College. Hort. Dep. University of Mosul, Iraq that will take place during the growing fall 2022 season . The purpose of the experiment was to further the growth and yield of cabbage plants under the specific conditions of Nineveh Governorate. It involved studying the effects of three factors:

1 - Two planting dates for sowing the seeds: the first date on August 27, 2025, and the second date on September 27, 2025.

2 - Two methods of applying the organic fertilizer "Tekamin Max": adding to soil and foliar spraying on the green mass. "Tekamin Max" is a liquid organic fertilizer derived from plant sources, containing 15% Total nitrogen as well as free amino acids including Serine, Arginine Proline, and Glutamic Acid.

3 - Three concentrations of the organic fertilizer "Tekamin Max": 0 ml/liter, 2.5 ml/liter, and 5 ml/liter.

The experiment comprised a total of 12 treatments, which were carried out in the field using a Factorial. Experiment. Within Split-plot design within the context of a Randomized. Complete. Block. Design. (RCBD). The sowing dates assigned to the main plots, while the combinations of application methods and concentrations of organic fertilizer were assigned in subplots. Three identical treatments were carried out in each group. Copenhagen Market cabbage variety was used for the experiment. The seeds were sown in lath house

at the Research Station pertaining to the Department of Horticulture within the College of Agriculture and Forestry using peat moss as the planting medium. Each planting tray contained 50 cells for planting. Once the plants have developed to the point where they are ready to be transplanted., which can be identified by having 4-5 true leaves, they were transplanting in the field on October 5, 2025, for the first planting date, and on November 10, 2025, for the second planting date. The field was divided into experimental units, with each unit measuring 2 meters in length and 1 meter in width. After transplanting, 12 cabbage plants were sowing on each side of the each unit of experimental, with a spacing of 33 cm between each plant.

Following are the characteristics that were investigated:

1 - The height of the plant, measured in centimeters from the part of the plant that is in contact with the earth to the leaf that is at the very top of the plant.

2 - No of rolled leaves ( $\text{leaf.plant}^{-1}$ ): To determine this, count all of the inner-leaves which comprise head, eliminating the leaves that are very little.

3 - Head weight average (g per head): Determined by dividing the overall output of the experimental unit divided by the total number of heads generated in each replicate of the experiment.

4 - The average weight of a marketable head is calculated in (g per head) by dividing the total number of heads in an unit of experimental by the total number of marketable heads generated by the plant. This calculation does not take into account the plant's outer leaves.

5 - Total yield of heads (ton per hectare): Calculated by summing up the total yield of heads from all experimental units and applying the appropriate equation.

The total yield = Yield of the experimental unit  $\times 10000 \text{ m}^2 / \text{Experimental area}$ .

6 - Marketable yield of heads (ton per hectare): Calculated using the same method as trait 5.

7 - Content of the growth hormones Gibberellic acid (GA3) and Andole acetic acid (IAA) in the leaves (nanograms per grams fresh weight): The hormone levels of IAA and GA3 were extracted and determined according to the method used by (Yavas *et al.*, 1997).

The results were analyzed statistically using computer software (SAS, 2017), compared means using

the Duncan multi-range test at a significance a value of 0.05 (AlRawi and Khalafallah, 2001).

## Results and Discussion

### *First: traits of growth and yield*

**Table.1** illustrates effect of sowing date, application method, and concentrations of the organic fertilizer TECAMIN MAX on vegetative growth and yield characteristics. The results indicate a significant superiority of plants sowing in the first date over those sowing in the second date in terms of plant height, number of rolled leaves, head of marketable weight, and market-able yield each unit of area. However, the remaining characteristics were not significantly affected by the difference in sowing date. Regarding the effect of application method, it is observed that adding to soil method significantly outperformed compared to foliar spraying method in terms of the marketable yield and the average weight of heads that are marketable each unit of area. The use of organic fertilizer, at both concentrations of 2.5 and 5 ml/liter, led to a significant increase in all studied characteristics compared to the control treatment, except for the concentration of 2.5 ml/liter, which only showed a discernible rise in the overall height of the plant. The highest significant values in all studied characteristics were obtained with the highest concentration of organic fertilizer.

The outcomes are presented in **Table 2** demonstrate the interactive consequence of sowing

date and application method on the growth and yield characteristics of cabbage plants. The results indicate that plants sowing in the first date and with adding to soil method gave the most important and relevant values in all studied characteristics and differed significantly from all other dual interaction treatments and across all characteristics.

The exam that Duncan took at the 5% degree of possibility reveals there is not a difference that can be backed up by statistical evidence between averages that have the same alphabetic letter.

The results of **Table 3** illustrate the interactive the influence of sowing date as well as the amount of organic fertilizer on the growth and yield characteristics of cabbage plants. The results of this table show that sowing the plants in the first date and treating them with a dosage of organic fertilizer of 5 ml/liter significantly outperformed compared to plants sowing in the second date and treated with both concentrations of fertilizer or untreated with organic fertilizer in all studied characteristics. Furthermore, the same treatment significantly outperformed all comparison treatments for the first date in all studied characteristics. Additionally, it showed significant superiority over plants that had a concentration of 2.5 ml/liter applied to them and sowing in the same date in terms of head weight, average marketable weight of head, total yield, and marketable yield each unit of area.

**Table 1:** Impact of sowing dates, application method and organic fertilizer on growth and yield traits of cabbage plants

Treatments	Characteristics of the study					
	Plant height (cm)	N° of rolled leaves	Head weight (g)	Marketable weight of head (g)	Total heads yield (ton)	Marketable yield heads (ton)
Sowing date						
First date	23.64 a	32.25a	1421.33a	862.08 a	85.280 a	51.725 a
Second date	19.72 b	29.19 b	1280.64 a	606.39 b	76.838 a	36.383 b
Application method						
Adding to soil	21.71 a	30.94 a	1409.83 a	783.11 a	84.590 a	46.987 a
Foliar spraying	18.71 a	30.50 a	1292.14 a	685.36 b	77.528 a	41.122 b
Levels of organic fertilizer (ml/liter)						
0	20.88 b	27.21 b	1066.29 c	534.42 c	63.978 c	32.065 c
2.5	21.68 ab	32.08 a	1402.00 b	793.67 b	84.120 b	47.620 b
5	22.50 a	32.88 a	1584.67 a	874.63 a	95.080 a	52.478 a

The exam that Duncan took at the 5% degree of possibility reveals there is not a difference that can be backed up by statistical evidence between averages that have the same alphabetic letter.

**Table 2 -** Impact of interaction between sowing dates and application method on growth and yield traits of cabbage plants

Treatments		Characteristics of the study					
Sowing date	Application method	Plant height (cm)	N° of rolled leaves	Head weight (g)	Marketable weight of head (g)	Total heads yield (ton)	Marketable yield heads (ton)
First date	Adding to soil	24.67 a	33.39 a	1558.6 a	948.83 a	93.517 a	56.930 a
	Foliar spraying	22.62 b	31.1 b	1284.0 b	775.33 b	77.043 b	46.520 b
Second date	Adding to soil	18.64 d	28.50 c	1261.0 b	617.39 c	75.663 b	37.043 c
	Foliar spraying	20.80 c	29.89b	1300.22 b	595.39 c	78.013 b	35.723 c

**Table 3** - Impact of interaction between sowing dates and organic fertilizer on features of growth and yield of cabbage plants

Treatments		Characteristics of the study					
Sowing date	Levels of organic fertilizer (ml/liter)	Plant height (cm)	No. of rolled leaves	Head weight (g)	Marketable weight of head (g)	Total heads yield (ton)	Marketable yield heads (ton)
First date	0	22.47 b	28.25 c	1068.6 c	602.58 d	64.115 c	36.155 d
	2.5	23.57 ab	34.50 a	1418.3 b	871.58 b	85.095 b	52.295 b
	5	24.90 a	34.00 a	1777.2 a	1112.08 a	106.630 a	66.725 a
Second date	0	19.28 c	26.17 d	1064.0 c	466.25 e	63.840 c	27.975 e
	2.5	19.78 c	29.67 c	1385.8 b	715.75 c	83.145 b	42.945 c
	5	20.10 c	31.75 b	1392.2 b	637.17 cd	83.530 b	38.230 cd

The exam that Duncan took at the 5% degree of possibility reveals there is not a difference that can be backed up by statistical evidence between averages that have the same alphabetic letter.

**Table 4** - Impact of interaction between application method and organic fertilizer on features of growth and yield of cabbage plants

Treatments		Characteristics of the study					
Application method	Levels of organic fertilizer (ml/liter)	Plant height (cm)	N° of rolled leaves	Head weight (g)	Marketable weight of head (g)	Total heads yield (ton)	Marketable yield heads (ton)
Adding to soil	0	21.00 bc	26.67 c	1179.8 cd	554.50 d	70.790 cd	33.270 d
	2.5	21.65 abc	33.58 a	1360.4 bc	766.33 bc	81.625 bc	45.980 bc
	5	22.32 ab	32.58 a	1689.3a	1028.50 a	101.355 a	61.710 a
Foliar spraying	0	20.75 c	27.75 c	952.8 d	514.33 d	57.165 d	30.860 d
	2.5	21.70 abc	30.58 b	1443.6 ab	821.00 b	86.615 ab	49.260 b
	5	22.68 a	33.17 a	1480.1 ab	720.75 c	88.805 ab	43.245 c

The exam that Duncan took at the 5% degree of possibility reveals there is not a difference that can be backed up by statistical evidence between averages that have the same alphabetic letter.

**Table 4** demonstrates the interactive effect of application method and levels of organic fertilizer on the growth and yield characteristics of cabbage plants. According to the shown in this table, the most important combination of two effects treatment in terms of plant height reached 22.6833 cm, which was achieved when using the adding to soil method with a concentration of 5 ml/liter of organic fertilizer. On the other hand, the best significant dual interaction treatment in terms of the number of rolled leaves was found when using the same method in combination with a concentration of 2.5 ml/liter of organic fertilizer. Furthermore, the adding to soil method combined with the a concentration of five ml/liter of organic fertilizer resulted in the highest significant values for head weight, average marketable head weight, total yield, and marketable yield per unit area. This differed significantly from most of the other treatments within this interaction for the mentioned characteristics.

Regarding the instance of the three-way interaction, effect between the study factors, the results of **Table 5** reveal that the highest significant values for average plant height, number of rolled leaves, head weight, average marketable head weight, total yield, and marketable yield per unit area were recorded as follows: 25.30 cm/plant, 35.67 leaves/plant, 2084.3 g/plant, 1415.50 g/plant, 125.060 tons/hectare, and 55.510 tons/hectare, respectively, these

values were obtained in the triple interaction

of the first sowing date, adding to soil method, and a concentration of 5 ml/liter of organic fertilizer. Based on these results, this triple interaction treatment was considered the best among all other triple interaction treatments. Therefore, this particular interaction treatment differed significantly from the majority of the several therapies for triple interactions.

The exam that Duncan took at the 5% degree of possibility reveals there is not a difference that can be backed up by statistical evidence between averages that have the same alphabetic letter.

*Second: Leaves contain of growth hormones Gibberellic acid (GA3) and Indole acetic acid (IAA).*

The results of **Figure 1** indicate that the plants grown at the first date were significantly superior in the leaf content of the growth hormone Gibberellic acid. As for the effect of organic fertilizer on this trait, the results show that both concentrations of TECAMIN MAX organic fertilizer used are significantly superior to the comparison plants. As for the interaction between planting dates and organic fertilizer concentrations, the results indicate that the plants grown on the first date treatment with a concentration of 5 ml /L of organic fertilizer, which provided the greatest value in the leaf content of the growth hormone Gibberellic acid, amounting to 54.333 nanograms per gram fresh weight, while the lowest value in this characteristic amounted to 25.079

**Table 5** - Impact of triple interaction between application method and organic fertilizer on features of growth and yield of cabbage plants

Treatments			Characteristics of the study					
Sowing date	Application method	Levels of organic fertilizer (ml/liter)	Plant height (cm)	No. of rolled leaves	Head weight (g)	Marketable weight of head (g)	Total heads yield (ton)	Marketable yield heads (ton)
First date	Adding to soil	0	23.70 ab	29.00 d	1196.2 bcd	613.00 de	71.770 bcd	36.780 de
		2.5	25.00 a	35.500 a	1395.3 b	818.00 bc	83.720 b	49.080 bc
		5	25.30 a	35.67 a	2084.3 a	1415.50 a	125.060 a	84.930 a
	Foliar spraying	0	21.23 cd	27.50 d	941.0 d	592.17 de	56.460 d	35.530 de
		2.5	22.13 bc	33.50 ab	1441.2 b	925.17 b	86.470 b	55.510 b
		5	24.50 a	32.33 b	1470.0 b	808.67 bc	88.200 b	48.520 bc
Second date	Adding to soil	0	18.30 e	24.33 e	1163.5 bcd	496.00 ef	69.810 bcd	29.760 ef
		2.5	18.00 e	31.67 bc	1325.5 bc	714.67 cd	79.530 bd	42.880 cd
		5	19.33 de	29.50 cd	1294.2 bcd	641.50 d	77.650 bcd	38.490 d
	Foliar spraying	0	20.27cde	28.00 d	964.5 cd	436.50 f	57.870 cd	26.190 f
		2.5	21.27 cd	27.67 d	1446.0 b	716.83 cd	86.760 b	43.010 cd
		5	20.87 cd	34.00 ab	1490.2 b	632.83 de	89.410 b	37.970 de

The exam that Duncan took at the 5% degree of possibility reveals there is not a difference that can be backed up by statistical evidence between averages that have the same

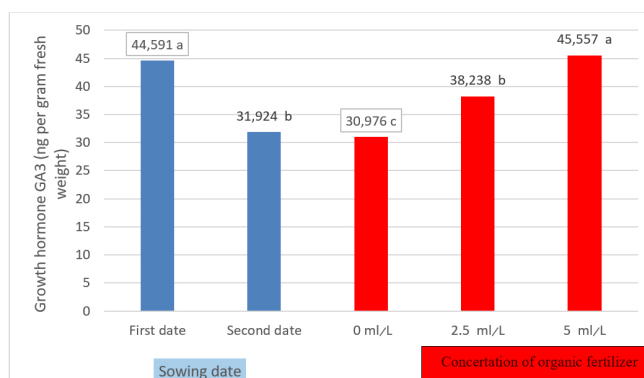
nanograms grams fresh weight recorded in the treatment of the overlap between the second sowing date in the comparison plants, **Figure 2**.

As for the effect of the study factors on the leaf content of the growth hormone Andole acetic acid, the results of **Figure 3** indicate that the plants grown at the first date were significantly superior in the leaf content of the growth hormone IAA. Regarding the effect of organic fertilizer on this trait, the results show that both concentrations of the TECAMIN MAX organic fertilizer used are significantly superior compared to comparison plants. As for the interaction between sowing dates and organic fertilizer concentrations, the results indicate that the plants grown on the first date and the treatment with a concentration of 5 ml /L of organic fertilizer, which provided the greatest value in the leaf content of growth hormone IAA, which amounted to 152.342 nanograms per gram fresh weight, while the lowest value in this characteristic amounted to 106.437 nanograms per gram fresh weight, recorded in the treatment of the interaction between the second planting date in the comparison plants, **Figure 4**.

The considerable increase in plant height, number of rolled leaves per plant and leaves contain of GA3 and IAA hormones for the plants in the first sowing date can be attributed to their exposure to favorable climatic conditions, including suitable temperature and duration of light, which promote good vegetative growth. This, in turn, increases the efficiency of nutrient

utilization during the photosynthetic process, leading to increased plant height and the formation of new leaves compared to the plants in the second planting date, which experienced lower temperatures and shorter periods of light, resulting in reduced efficiency of nutrient utilization during photosynthesis and, consequently, lower plant height and leaf formation. These explanations are supported by previous studies conducted by (Potter *et al.*, 1999, Galwey and Dehanayake, 1999 and Ibraheem, 2007, Hameed and Salim, 2022), which confirmed that the leaves number in most cruciferous plants increases with higher temperatures and longer photoperiods.

As for the significant increase in the average head weight, weight typical of those sold on the market, total yield, and marketable yield each unit of area



**Figure 1.** Effect of sowing date and organic fertilization on the GA3 growth hormone content in leaves

when using the soil incorporation method compared to the spraying method, it may be due to the nature of the cabbage leaf structure, which has a waxy layer that potentially reduces the penetration of organic fertilizer into the plant cells. Therefore, the soil incorporation method may directly affect the root system, facilitating the movement and distribution of organic fertilizer into the plant through the root system. Consequently, plants treated with this method exhibited significant superiority over plants treated with organic fertilizer through foliar

application.

The significant effect of organic fertilizer, at both concentrations, on all studied characteristics mentioned in Table (1) and figures 1-4 special forms of growth hormones GA3 and IAA, except for plant height, which was not significantly affected when using a concentration of 2.5 ml/liter, may be attributed to the richness of organic fertilizer in nitrogen and amino acids, as mentioned in the materials and methods section. Numerous studies have reported noticeable improvements in terms of both growth and yield qualities of cabbage when using organic fertilization, supporting these findings (Saadoon and Abd Ghali, 2014, Mohammed and Manea, 2018 Chaudhary *et al.*, 2018).

**Conclusions**

Based on this study, to enhance the growth and productivity characteristics of cabbage plants, we recommend planting the cabbage plants using the first sowing date and following the adding to soil method when applying the liquid compost TECAMIN MAX of 5 ml/liter. This recommendation is based on the significant effects observed when these three factors interacted when it comes to the majority of the vegetative development and yield features of the plants.

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**References**

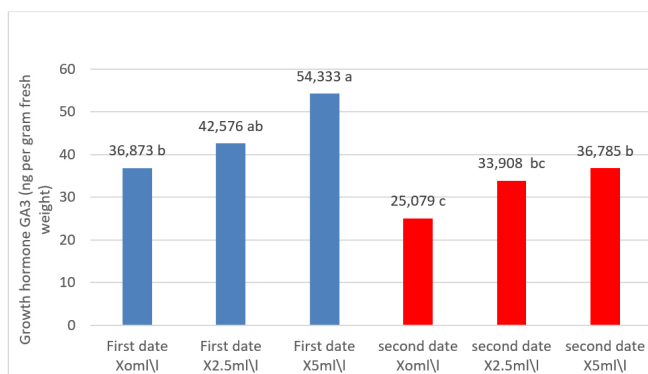
Abd Alla, M.A., El-Greadly, N.H., Emam, Y.T. 2015. Effect of Foliar Spray with Biostimulants on Growth, Head Yield, Phytohormones and Nutrients of Cabbage (Brassica oleracea var. Capitata). Egyptian Journal of Horticulture, 42: 707-719.

Abdul-Wahid, QB. 2020. Physiological Study to Improve the Growth and Yield of squash (Cucurbita pepo L.) (Master dissertation, College of Agriculture and Forestry, University of Mosul, Ministry of Higher Education and Scientific Research, Iraqi Republic).

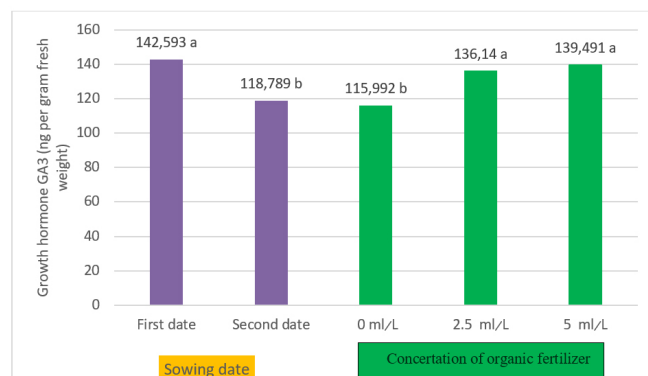
AlRawi, K.M., Khalafallah A.A.M. 2001. Design and Analysis of Agricultural Experiments. University of Mosul: Ministry of Higher Education and Scientific Research, Dar Alkutub for Printing and Publishing, Republic of Iraq, 513pp.

Al-Chalabi, A.T.M., Ibraheem, F.F., Hussein, A.M., Alsawaf, A. 2023. Comparison the effect of an organic nutrient (Nektafol) under production and open field condition on the growth and yield of lettuce. In IOP Conference Series: Earth and Environmental Science 1262: 042003.

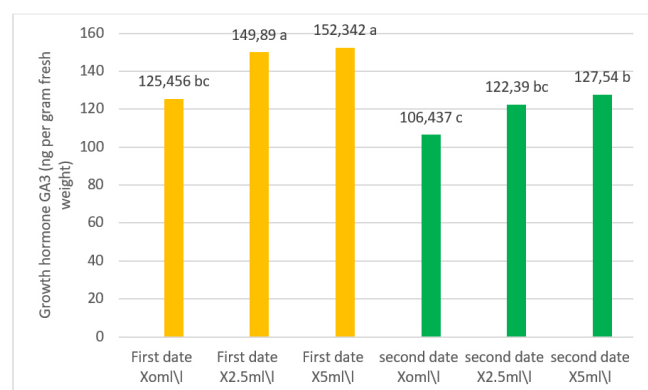
Aman, A.S., Kumar, A., Kumar, P., Mishra, P.K., & Mohan, M. 2022. Implementation of An Effective and Successful



**Figure 2:** Effect of interaction between sowing date and organic fertilization on the GA3 growth hormone content in leaves



**Figure 3:** Effect of sowing date and organic fertilization on the IAA growth hormone content in leaves



**Figure 4:** Effect of interaction between sowing date and organic fertilization on the IAA growth hormone content in leaves

- Management Tactics against Diamondback Moth (*Plutella xylostella* L.) on Cabbage. *International Year of Millets* 47: 207-212.
- Chaudhary, S.K., Yadav, S.K., Mahto, D.K., Sharma, R.P., Kumar, M. 2018. Response of growth, yield attributes and yield of cabbage (*Brassica oleracea* var. *capitata*) to different organic and inorganic sources of nutrients in Magadha plain of Bihar. *International Journal of Current Microbiology and Applied Sciences* 3: 4748-4756.
- Debrah, P.Y., Afriyie-Debrah, C., Nuhu, F., Ribeiro, P., Obeng, E.A. 2021. Response of Cabbage (*Brassica oleracea* var. *capitata* L.) to Organic and Inorganic Fertilizer. *Journal of Experimental Agriculture International* 43: 105-114.
- Farjana, S., Islam, M.A., Haque, T. 2019. Effects of organic and inorganic fertilizers, and mulching on growth and yield of cabbage (*Brassica oleracea* var. *capitata* L.). *Journal of Horticulture and Postharvest Research* 2: 95-104.
- Galwey, S.R., Dahanayake, N.W. 1999. Effects of interactions between low-temperature treatments, gibberellin (GA3) and photoperiod on flowering and stem height of spring rape (*Brassica napus* var. *annua*). *Annals of Botany*, 84: 321-327. □
- Hassan, A. A. M. (2012). *Vegetable Crop Production*. Dar Alarabia for Publishing and Distribution, Cairo, Egypt. 312pp.
- Hameed, A.I., Salim, A.F. 2022. The effect of three depths of subsurface drip irrigation levels with two types of soil on the percentage of soil moisture content. *Jurnal Teknologi (Sciences & Engineering)* 84: 149-157.
- Ibraheem, F. F. R. (2007). Effect of planting dates and spraying with gibberellic acid on the growth and yield of two cultivars of cauliflower (*Brassica oleracea* var. *botrytis*) (Master dissertation, College of Agriculture and Forestry, University of Mosul, Ministry of Higher Education and Scientific Research, Iraqi Republic).
- Ibraheem, F. F. R. (2012). Physiological role of calcium, licorice, soluamine extracts and application methods to decrease water stress damage and to improve growth, yield and quality characteristics of potato (Doctoral dissertation, College of Agriculture and Forestry, University of Mosul, Ministry of Higher Education and Scientific Research, Iraqi Republic).
- Iddrisu, S., Essilfie, M. E., Bolfrey-Arku, G. 2021. Response of Cabbage (*Brassica oleracea* var. *capitata*) to Organic and Inorganic Fertilizers on Growth and Yield Parameters and Incidence of Insect Pest. *International Journal of Environment, Agriculture and Biotechnology*, 6: 6-12.
- Liu, W., Muzolf-Panek, M., Kleiber, T. 2022. Effect of Nitrogen Nutrition and Planting Date on the Yield and Physicochemical Parameters of Flowering Chinese Cabbage. *Agronomy*, 12: 2869-2879.
- Mohammed, S.A.K., Manea, A.I. 2018. Response of two Cabbage cultivars (*Brassica oleracea* var. *Capitata*) to organic and chemical fertilization. *Euphrates Journal of Agriculture Sciences* 10: 141-153.
- O'Dell, C. R. 2009. Natural plant hormones are biostimulants helping plants develop higher plant antioxidant activity for multiple benefits. Vergina: State University, 1339 pp.
- Potter, T.I., Rood, S.B., Zanewich, K.P. 1999. Light intensity, gibberellin content and the resolution of shoot growth in Brassica. *Planta*, 207:505-511.
- Saadoon, S.A.H., Abd Ghali, A.A. 2014. Response of Cabbage Varieties (*Brassica oleracea* var. *capitata* L.) to Folia Spray of Compost extract (date palm leaves) and Its Effects on Leaves Content of N and K, Yield and Quality Characteristics of heads. *Kufa Journal for Agricultural Sciences* 6: 32-41. □
- SAS, (2017). *Statistical Analysis System User,s Guide . Version 15*. Statistical Analysis System Institute. North Carolina: Cary Inc, USA, pp458.
- Shamad, A., Singh, D., Prasad, V.M., Bahadur, V., Singh, V. 2023. Efficacy of Organic Manure and age of Seedling on Growth and Yield of Hybrid Cabbage (*Brassica oleracea* var. *capitata*). *International Journal of Plant & Soil Science* 35: 282-287.
- Sidoine, D.E., Xavier, M.K. 2022. Combined Effect of Planting Date, Organic Fertilization and Cabbage Varieties on Cabbage and Turnip Aphids and their Natural Enemies in Dschang, Cameroon. *South Asian Research Journal of Biology and Applied Biosciences* 4: 74-85.
- Talalay, P., Fahey, J.W. 2001. Phytochemicals from cruciferous plants protect against cancer by modulating carcinogen metabolism. *The Journal of nutrition* 131: 3027S-3033S.
- Tendaj, M., Sawicki, K. 2012. The effect of the method and time of seedling production on red cabbage (*Brassica oleracea* L. ssp. *oleracea* convar. *capitata* (L) Alef. var. *capitata* L. f. *rubra* DC.) yield. *Acta Agrobotanica*, 65: 9-17.
- Ullah, A., Islam, M. N., Hossain, M. I., Sarkar, M. D., & Moniruzzaman, M. 2013. Effect of planting time and spacing on growth and yield of cabbage. *International journal of Bio-resource and Stress Management* 4: 182-186.
- Yavas, A., Ozmen, M., Topcuoglu, S. F. 1997. Analysis of gibberellic acid, abscisic acid, indole-3-acetic acid and zeatin from the selected tissues of albino mice. *Toxicological & Environmental Chemistry* 59: 251-260.
- Yadav, R., Ahamad, S., Raj, M. 2022. Effect of different planting time and spacing on growth, yield and quality of cabbage (*Brassica oleracea* var. *capitata*) cv. Golden Acre under Bundelkhand region in U.P. *International Journal of Chemical Studies*, 9: 358-363.
- Wszelaki, A., Kleinhenz, M.D. 2003. Yield and relationships among head traits in cabbage as influenced by planting date and cultivar. II. Processing. *HortScience* 38: 1355-1359.

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