# Effect of Method and Concentrations of High-Phosphorus Fertilizer Application on Growth and Yield of Cabbage Plants Brassica oleracea var.capitata L.

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## Abstract

Agricultural Research Station affiliated with the College of Agriculture, University of Basrah, in the Karamat Ali area. The study aimed to evaluate the effect of adding high phosphorus fertilizer at different concentrations (0, 1, 2, 3) g L-1 and by two methods (foliar spray and soil addition with irrigation water) on the growth and yield of cabbage plants. The results showed a significant superiority of the 3 g L-1 concentration in plant height (34.67 cm), stem diameter (2.771 cm), leaf area (154.2 dm²), number of non-wrapped leaves (18.67 leaves) and inner leaves (36.50 leaves), fresh weight of the plant (2.734 kg), head circumference (55.0 cm), head weight (2.130 kg), and total yield (46.86 tons ha-1). The method of addition did not differ significantly in most of the studied traits. The interaction between the two study factors showed a significant effect on most of the studied traits, where plants added with high phosphorus fertilizer at a concentration of 3 g L-1 with irrigation water gave the highest head weight and total yield, reaching 2.180 kg and 47.96 tons ha-1, respectively.

**Keywords: Cabbage plant, High phosphorus fertilizer, Fertilizer concentrations, Application method, Growth, Yield.**

## Introduction

Cabbage, Brassica oleracea var. Capitata, belonging to the Cruciferae family. The head, which consists of tightly packed leaves, is consumed fresh or used in pickles and salads (1). Every 100 grams of fresh leaves contain 88.8-93.9% water, 6.1-11.2% dry matter, 3-5.4% carbohydrates, 1-2% proteins, 0.2% fats, 49 mg phosphorus, 238 mg potassium, 30-50 mg vitamin C, 130 IU vitamin A, and 24 calories (5.(

Cabbage has numerous medicinal benefits, including treating stomach and duodenal ulcers, reducing blood sugar levels, and protecting against cancer (13.(

Globally, cabbage production reached 71707238.96 million tons from 2450601million hectares, with an average yield of 29.261 tons per hectare. In Iraq, the cultivated area was approximately 4401 hectares, producing 11687 tons with an average yield of 10.622 tons per hectare (6). One of the key factors in increasing production per unit area is phosphorus fertilization, which is an essential macronutrient for plant growth, playing a crucial role in photosynthesis, respiration, cell division, and ion uptake (8). Phosphorus also promotes root growth, stem strength, and improves yield quality and earliness (11.(

However, most Iraqi soils have high calcium carbonate content and alkaline pH, leading to phosphorus fixation and precipitation, which can limit its availability to

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plants during certain growth stages (4). Many studies suggest that 85% of plant nutrient requirements can be met through foliar feeding, especially when soil absorption is problematic (10). (9) observed that applying 60 kg ha-1 of phosphorus resulted in the highest yield, head circumference, diameter, weight, and leaf number in cabbage. Similarly, (7) found that increasing phosphorus levels (0, 36, 116, 168 kg ha-1) significantly improved marketable yield. (2) reported that spraying cauliflower (Brassica oleracea var. botrytis L.)with a high-phosphorus fertilizer (10-52-10) at concentrations of 0, 1, and 2 g L-1 showed superior results at 2 g L-1 for stem diameter, leaf number, leaf area, fresh weight, and yield. Due to the limited studies on the method and concentrations of high phosphorus fertilizer application and their interaction on cabbage growth and yield under Basrah conditions, this study was conducted .

## Materials and Methods

The current experiment was conducted at the Agricultural Research Station, College of Agriculture, University of Basrah, during the winter season of 2023-2024. The land was plowed, leveled, and amended with animal manure at a rate of 10 tons per dunum. The land was then divided into three ridges, each 1 meter apart and 40 cm wide, with drip irrigation lines installed above each ridge.

Cabbage seedlings were transplanted to the field after approximately 45 days from sowing, with 5-7 true leaves per seedling, and spaced 40 cm apart. The field was divided into three replicates, each containing four treatments for both foliar spray and soil application methods, resulting in a total of 24 treatments (4 concentrations × 2 application methods × 3 replicates.(

The seedlings were treated with four concentrations of high-phosphorus compound fertilizer (0, 1, 2, and 3 g L-1) in three applications during the study season. The first application was on November 15, 2023, followed by two more applications at two-week intervals.

Experimental measurements were taken two weeks after the last application and included vegetative growth indicators and yield, measured at the end of the season (1). These measurements included:

- Plant height (cm(
- Number of non-wrapped leaves (leaves plant-1) - calculated for each head.
- Number of wrapped leaves (leaves plant-1) - the number of wrapped leaves was calculated for each head, excluding small leaves.
- Weight of non-wrapped leaves (kg(
- Weight of wrapped leaves (kg(
- Total plant weight (kg) - calculated for the entire plant, including non-wrapped leaves.
- Head diameter (cm) - measured using a measuring tape, averaging the number of heads per experimental unit.
- Leaf area ($dm^2$) - calculated according to the method described by (14.(
- Head weight (kg) - calculated by dividing the weight of the heads for the experimental unit by the number of plants in the experimental unit.

The experiment was conducted using a split-plot design with three replicates, and The means were compared according to the Least Significant Differences Test (L.S.D) at the probability level of 0.05 using the Genstatic Statistical analysis system .

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**Table (1) Some Physical and Chemical Properties of the Experimental Field Soil and Irrigation Water**

| **Property** | **Value** |
|---|---|
| Sand g kg $^{-1}$ | 54.3 |
| Silt g kg $^{-1}$ | 312.2 |
| Clay g kg $^{-1}$ | 103.5 |
| Soil Texture | Silty Clay |
| Total Nitrogen mg kg$^{-1}$ | 22.63 |
| Available Phosphorus mg kg$^{-1}$ | 7.19 |
| Available Potassium mg kg$^{-1}$ | 19.87 |
| Electrical Conductivity (EC) ds m$^{-1}$ | 4.12 |
| pH Level | 7.28 |
| **Irrigation Water Properties** | |
| **(EC) ds m$^{-1}$** | 2.5 |
| **(pH)** | 7.3 |

Results and Discussion

It is evident from Table (2) that the method of high-phosphorus fertilizer application significantly affected plant height and the number of wrapped leaves only, while it did not significantly affect stem diameter, leaf area, and the number of non-wrapped leaves. The irrigation method significantly increased plant height by 6.43% compared to foliar spraying, which in turn caused a significant increase in the number of wrapped leaves by 7.43% compared to soil application.

The same table shows that the application concentrations significantly affected all the studied traits. Plant height, stem diameter, and the number of non-wrapped leaves increased significantly with increasing application concentrations. Plants fertilized with a concentration of 3gL-1 gave the highest values for these traits, with percentage increases for plant height of 45.48%, 26.07%, and 8.34%, for stem diameter of 53.68%, 25.49%, and 15.31%, and for the number of non-wrapped leaves of 30.28%, 11.99%, and 10.93%, compared to the control treatment and the concentrations of 1 and 2 g L-1, respectively .

The concentrations of 2 and 3 g L-1 significantly excelled in increasing leaf area compared to the control treatment, with percentage increases of 43.40% and 58.96%, respectively. The concentration of 1 g L-1 did not differ significantly from the other concentrations for this trait. Regarding the number of wrapped leaves, the concentrations of 2 and 3 g L-1 significantly excelled compared to the control treatment and the concentration of 1 g L-1, with percentage increases of 33.11%, 17.14%, and 34.39%, 25.12%, respectively. The concentration of 1 g L-1 also significantly excelled compared to the control treatment, with a percentage increase of 13.63%

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**Table (2) Effect of Method and Concentrations of High-Phosphorus Fertilizer Application and Their Interaction on Some Vegetative Growth Indicators of Cabbage Plants**

| Treatments | | | Plant Height | Stem Diameter | Leaf Area ($dm^2$) | Number of Non-Wrapped Leaves | Number of Wrapped Leaves |
|---|---|---|---|---|---|---|---|
| Average Effect of Addition Method | Spraying | | 28.58 | 2.304 | 132.7 | 16.83 | 32.50 |
| | Irrigation | | 30.42 | 2.288 | 124.9 | 16.92 | 30.25 |
| L S D 0.05 | | | **1.04** | **N.S** | **N.S** | **N.S** | **1.94** |
| Mean Effect of Phosphate Fertilizer Concentration ($g\ L^{-1}$) | | 0 | 23.83 | 1.803 | 970.0 | 14.33 | 25.67 |
| | | 1 | 27.50 | 2.208 | 125.0 | 17.67 | 29.17 |
| | | 2 | 32.00 | 2.403 | 139.1 | 16.83 | 34.17 |
| | | 3 | 34.67 | 2.771 | 154.2 | 18.67 | 36.50 |
| L S D 0.05 | | | 1.47 | 0.266 | 38.0 | 0.82 | 2.74 |
| Interaction Between Method and Concentrations of Addition | Spraying | 0 | 22.00 | 1.807 | 103.7 | 13.67 | 26.33 |
| | | 1 | 26.00 | 2.215 | 116.0 | 17.67 | 30.00 |
| | | 2 | 31.00 | 2.339 | 145.5 | 17.00 | 35.67 |
| | | 3 | 35.33 | 2.857 | 165.8 | 19.00 | 38.00 |
| | Irrigation | 0 | 25.67 | 1.799 | 90.30 | 15.00 | 25.00 |
| | | 1 | 29.00 | 2.201 | 134.0 | 17.67 | 28.33 |
| | | 2 | 33.00 | 2.466 | 132.6 | 16.67 | 32.67 |
| | | 3 | 34.00 | 2.685 | 142.7 | 18.33 | 35.00 |
| L S D 0.05 | | | **2.09** | **N.S** | **N.S** | **1.17** | **N.S** |

The interaction between the two study factors showed a significant effect on plant height and the number of non-wrapped leaves only. Plants fertilized with a foliar spray at a concentration of 3 g L-1 gave the highest values for these two traits, reaching 35.33 cm and 19.00 leaves, respectively. In contrast, plants not sprayed with phosphate fertilizer gave the lowest values, reaching 22.00 cm and 13.67 leaves, respectively.

Table (3) shows that the method of addition significantly affected the fresh weight of the plant only, with the foliar spray method excelling with a percentage increase of 14.17% compared to soil application with irrigation water.

The method of addition did not have a significant effect on head circumference, head weight, and total yield.

It appears from the same table that the concentration of high-phosphorus fertilizer application significantly affected all yield traits. The concentrations of 2 and 3 g L-1 caused a significant increase in plant fresh weight compared to the control treatment and the concentration of 1 g L-1, with percentage increases of 98.90%, 56.29%, and 114.7%, 68.76%, respectively. There was no significant difference between the two concentrations, while the concentration of 1 g L-1 significantly excelled compared to the control treatment, with a percentage increase of 27.25%.

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**Table (3) Effect of Method and Concentrations of High-Phosphorus Fertilizer Application and Their Interaction on Some Yield Indicators of Cabbage Plants**

| Treatments | | | Fresh Weight of Plant (kg) | Head Circumference (cm) | Head Weight (kg) | Total Yield (ton $ha^{-1}$) |
|---|---|---|---|---|---|---|
| Average Effect of Addition Method | | Spraying | 2.175 | 45.17 | 1.642 | 36.12 |
| | | Irrigation | 1.905 | 46.08 | 1.562 | 34.37 |
| L S D 0.05 | | | 0.201 | N.S | N.S | N.S |
| Mean Effect of Phosphate Fertilizer Concentration ($g L^{-1}$) | | 0 | 1.273 | 36.83 | 0.847 | 18.64 |
| | | 1 | 1.620 | 41.83 | 1.578 | 34.72 |
| | | 2 | 2.532 | 48.83 | 1.853 | 40.76 |
| | | 3 | 2.734 | 55.00 | 2.130 | 46.86 |
| L S D 0.05 | | | 0.283 | 2.16 | 0.166 | 3.65 |
| Interaction Between Method and Concentrations of Addition | Spraying | 0 | 1.278 | 37.00 | 0.824 | 18.14 |
| | | 1 | 1.832 | 39.67 | 1.656 | 36.44 |
| | | 2 | 2.665 | 49.00 | 2.007 | 44.16 |
| | | 3 | 2.923 | 55.00 | 2.080 | 45.76 |
| | Irrigation | 0 | 1.268 | 36.67 | 0.870 | 19.14 |
| | | 1 | 1.408 | 44.00 | 1.500 | 33.00 |
| | | 2 | 2.398 | 48.67 | 1.698 | 37.36 |
| | | 3 | 2.545 | 55.00 | 2.180 | 47.96 |
| L S D 0.05 | | | N.S | 3.06 | 0.235 | 5.17 |

The addition concentrations significantly excelled in increasing head circumference and total yield compared to the control treatment, and the effect increased significantly with increasing concentration. The concentration of 3 g L-1 gave the highest values for these traits, with percentage increases for head circumference of 49.33%, 31.48%, and 12.63%, and for head weight and total yield of 151.47%, 34.98%, and 14.94%, compared to the control treatment and the concentrations of 1 and 2 g L-1, respectively. The interaction between the two study factors showed a significant effect on head circumference and total yield.

Plants fertilized with high-phosphorus fertilizer using both methods at a concentration of 3 g L-1 gave the largest head circumference, reaching 55.0 cm. Plants fertilized with irrigation gave the highest values for head weight and total yield, reaching 2.180 kg and 47.96 tons ha-1, respectively. The lowest values for head circumference were in plants not fertilized with high-phosphorus fertilizer using the irrigation method, reaching 36.67 cm. The lowest values for head weight and total yield were in plants not sprayed with fertilizer, reaching 0.827 kg and 18.14 tons ha-1, respectively.

The results Depends on the tables show that the method of adding high-phosphorus fertilizer to cabbage plants did not have a significant impact on plant growth and yield. This may be due to several factors, including crop type, soil type, fertilizer type, and

cultivation method. Each method has its advantages in delivering nutrients to the plant. In the case of soil application with irrigation water, the element is directly supplied to the root system. Foliar spraying is a quick way to treat symptoms of nutrient deficiency and is used when there are obstacles to nutrient absorption by the root system due to disease or problems such as fixation, precipitation, or salinity (12.(

The significant superiority of adding high-phosphorus fertilizer in growth and yield traits of cabbage plants may be attributed to its role in cell formation and division, increasing carbohydrate accumulation rates due to enzyme stimulation, and the formation of food materials resulting from photosynthesis to release energy necessary for biological processes within the plant (3; 8). This improves vegetative growth and has a positive impact on forming a strong root system, increasing nutrient absorption efficiency, and thus increasing nutrient concentration in the plant. This, in turn, leads to an increase in manufactured food materials and their transfer to plant parts (11). These results are consistent with those obtained by (9) and (7) in cabbage and (2) in cauliflower.

This study concludes that adding high-phosphorus fertilizer to cabbage plants grown under the conditions of Basrah city in the Karamat Ali area, directly to the soil with irrigation water or as foliar feeding at a concentration of 3 g L-1, led to increased growth and yield

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