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# MORINGA LEAF EXTRACT AND MINERAL FERTILIZER EFFECT ON THE GROWTH AND YIELD TRAITS OF THE CABBAGE

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## SUMMARY

This study aimed to evaluate the effect of moringa leaf extract and mineral fertilizer on the growth and yield traits of cabbage (*Brassica oleracea* L.), carried out during the growing season of 2024 at the University of Mosul, Mosul, Iraq. The experiment layout was in a randomized complete block design (RCBD) with two factors: a) foliar application of moringa leaf extract (M) (0, 5, and 10 ml $L^{-1}$) and urea fertilizer (U) (0, 4, and 6 g $L^{-1}$) and three replications, resulting in 27 treatments. The study used hybrid cauliflower seeds (Green Stream). The foliar application of moringa leaf extract and urea fertilization significantly improved the growth parameters, such as head circumference, plant height, the number of leaves, petiole thickness, chlorophyll content, and stem length. Likewise, the treatments enhanced productivity indicators (head weight and total yield) compared with the control treatment. The most effective integrated treatment was the foliar application of moringa extract (10 ml $L^{-1}$) combined with urea fertilizer (6 g $L^{-1}$), which resulted in the highest productivity of cabbage.

**Keywords:** Cabbage (*B. oleracea* L.), moringa leaf extract, mineral fertilizer, chlorophyll content, growth and yield traits, cabbage, weight and total yield

**Key findings:** The most effective integrated treatment was the foliar application of moringa leaf extract (10 ml $L^{-1}$) combined with urea fertilizer (6 g $L^{-1}$), resulting in the highest productivity of cabbage (*B. oleracea* L.).

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## INTRODUCTION

Cabbage (*Brassica oleracea* L. var. capitata) belongs to the family Brassicaceae, which is one of the largest plant families. Cabbage is a cool-season crop that grows well in moist and cold climates, optimally in cool temperatures. Its cultivation centers mainly on its large heads, composed of various layers of leaves. Cabbage growing can occur in diverse soil types, but it thrives in moist, well-drained, and nutrient-rich clay soils. Cabbage requires large amounts of plant nutrients, especially nitrogen, to increase the chlorophyll content and produce edible heads. However, due to poor growth and development of the said vegetable crop, less production transpires at the vegetable farms.

Some food commodities essential in the fulfillment of human nutritional needs include various vegetables (Temu and Temu, 2005). High-value crops are the healthy vegetables, including cabbage, for their significant worth. Such types of vegetables provide the highest sources of vitamins, minerals, and fibers. However, according to past investigations, half of the sub-Saharan African countries are suffering from a shortage of these vegetable crops, as classified by the Food and Agriculture Organization (FAO) (Stock, 2004).

Inorganic fertilizer treatment can be effective for plant leaves by foliar application. However, these fertilizers are expensive, and their excessive use makes plants less productive while polluting the environment. Organic fertilizers, on the other hand, come entirely from natural raw materials and are referred to as liquid concentrates that contain organic elements without causing environmental damage. Past studies enunciated the application of organic fertilizers and seaweed extract significantly improved the growth characteristics and yield of various crop plants and outperformed the control treatment (Al-Zubaidy, 2023, 2024).

Growth-promoting substances applied topically also enhanced crop growth and development and eventually boosted production (Adams and Adams, 2002; Al-Hakimi and Hamada, 2011; Azeem and Ahmad, 2011). The growth regulators reached categorization into five groups, i.e., abscisic acid, auxins, gibberellins, ethylene, and cytokinins (Prosecus, 2006). The natural substances are inexpensive and ecologically beneficial, making the farming community prefer their use. Among the effective means of utilizing low-cost technology is relying on natural nutrient sources (organic materials) to enhance crop productivity without polluting the environment, such as using the moringa leaf extract.

Moringa alleviates the need to apply inorganic fertilizer while boosting the growth levels of crop plants. Applying the moringa leaf extract on the plant foliage extends the plant's life and enhances roots, stems, and weight, eventually producing larger fruits for higher productivity (Foidle *et al*., 2001). Similarly, moringa leaf extract treatment has considerably improved yields in other crops, including onion, pepper, soybean, sorghum, coffee, tea, chili, melon, and maize (Fuglie, 2000).

Research also suggested that combining a higher amount of organic fertilizer with reduced inorganic nitrogen fertilizer can enhance the storage and nutritional quality of cabbage heads (Yadav *et al*., 2001; Londhe, 2002). Both organic and inorganic nutrients in integration have a significant impact on cabbage productivity, acquiring effects from residual inorganic fertilizers. Therefore, the preferred fertilizers would be the organic fertilizers. Organic fertilizers are also favorable in promoting the productivity and quality of various crops (Tindall, 2000).

Soil forms the foremost ingredient of crop production since it is the major source of plant nutrients. Humans have developed soil-based crop cultivation and discovered mineral deposits for plant nutrients like phosphorus, potassium, and sulfur. Nutrient management is crucial in limiting the crop production levels (Liu *et al*., 2010). Therefore, proper fertilizer application rates are critical for increasing cabbage productivity and ensuring its sustainability.

Numerous studies revealed the application of nitrogen multiplies the overall cabbage yield (Patrick *et al*., 2012). This is, however, possible only when its treatment is in

moderation, in terms of the rate and timing. The highest cabbage yield can emerge by controlling the levels of nitrogen fertilizers. Therefore, ignorance concerning this factor will hamper the cabbage production if one does not know how to apply the right rate of fertilizer. Based on the above discussion, the following study aimed to determine the effect of moringa leaf extract (as organic fertilizer) and mineral fertilizer (urea) on the growth and yield traits of cabbage (*B. oleracea* L.).

## MATERIALS AND METHODS

The presented experiment on the effect of moringa leaf extract and mineral fertilizer (urea) on the growth and yield traits of cabbage (*B. oleracea* L.) commenced during the growing season of 2024 at the University of Mosul, Mosul, Iraq. The experiment layout was in a randomized complete block design (RCBD), with two factors: a) foliar application of moringa leaf extract (0, 5, and 10 ml $L^{-1}$) and b) urea fertilizer (0, 4, and 6 g $L^{-1}$) and three replications, resulting in 27 treatments.

Before transplanting the cabbage seedlings, the soil leveling and preparation ensued. The NPK chemical fertilizer application entailed thorough mixing with the soil to ensure even distribution across all the treatments (Table 1). The field sustained divisions into three replications, each containing nine experimental units. The promotion of crop development involved combining hybrid cauliflower seeds (Green Stream) with urea fertilizer at concentrations of 0, 4, and 6 g $L^{-1}$ and moringa leaf extract at concentrations of 0, 5, and 10 ml $L^{-1}$ through foliar application.

The initial sowing of cabbage seeds proceeded in trays filled with peat moss in the nursery. The seedlings at the 3–4 leaf stage (after 35–40 days) underwent transplanting during the morning in the field. Each experimental unit covered an area of 3.5 m², containing two rows with eight seedlings per row (16 seedlings per unit). A spacing of 40 cm remained between the seedlings and 0.75 cm spacing between the experimental units to avoid the treatments' interference. Protective buffer units succeeded in planting at the beginning and end of each block.

An installation of a drip irrigation system helped enhance the effective distribution of water. Weeding and hoeing continued regularly to remove the unwanted plants around the cabbage seedlings. Field pest control involved spraying plants with an insecticide, 'Nurell-D,' at 1 ml/L of water 25 days after transplanting to combat the aphids and chewing insects. These steps ensured an organized experiment and accurate final results.

### Moringa leaf extract application

The harvested fresh moringa leaves sustained drying in a ventilated room before grinding well into a fine powder using an electric grinder. A specific quantity of powder underwent weighing and placing in a 1-liter beaker. Adding hot distilled water at 65 °C preceded the mixture's soaking for 24 h to extract active compounds (Table 2). The solution entailed filtration through a filter paper, increasing its volume to one liter using distilled water to achieve the desired concentration. Four foliar applications of moringa leaf extract proceeded for each treatment at 15-day intervals, starting after one month of transplanting. Four experimental units received random selection, with five plants in each experimental unit measured at the maturity stage to assess the treatment effects.

### Traits studied and statistical analysis

The data recorded on traits comprised head circumference (cm), chlorophyll percentage (%), petiole thickness (cm), stem length (cm), plant height (cm), stem diameter (cm), marketable head weight (kg), the number of marketable leaves, non-marketable head weight (kg), and total yield per hectare (ha). The calculation for the total yield was as follows, then undergoing comparison according to the least significant difference ($LSD_{0.05}$) test.

Total yield (t $ha^{-1}$)= $\frac{experimental\ unit\ yield\ (\ tons) \times 10000}{experimental\ unit\ area(m2)}$

**Table 1.** The physical and chemical characteristics of the experimental soil before planting.

| Parameters | Unit | Value |
|---|---|---|
| EC | dc.m-1 | *0.2*6 |
| PH | _____ | *.750* |
| Nitrogen | *%* | *0.138* |
| Phosphorus | PPm | *8*.34 |
| Potassium | PPm | *125.2*55 |
| Clay | *%* | *17* |
| Grean | *%* | *16* |
| Sand | *%* | *7*4 |
| Textured | _____ | Loamy sand |

**Table 2.** The maximum and minimum temperatures, average wind speed, and rainfall recorded during the growing season.

| Months | Average maximum temperature (°C) | Average minimum temperature (°C) | Average wind speed (m/s) | Rainfall rate (mm) |
|---|---|---|---|---|
| November | 23.1 | 20.9 | 22.9 | 7.2 |
| December | 20.0 | 12.6 | 139.9 | 5.5 |
| January | 16.8 | 8.3 | 97.6 | 3.4 |
| February | 13.4 | 5.4 | 36.2 | 6.5 |
| March | 13.4 | 7.4 | 36.9 | 11.4 |
| April | 15.6 | 8.4 | 127.6 | 5.6 |

## RESULTS AND DISCUSSION

The results from Tables 3 and 4 revealed that foliar application of moringa extract and urea fertilization compelled the cabbage (*B. oleracea* L.) plants to grow faster and more productively than the control treatment. The growth and yield parameters, such as head circumference, plant height, leaf number, petiole thickness, stem length, and chlorophyll content, were evident with improved values, especially with the interaction of moringa leaf extract and urea fertilizer. The studies by Fuglie (2000) confirmed that zeatin (the most common cytokinin) found in moringa extract maintains larger leaf areas, boosting photosynthetic activity and chlorophyll content. These results were also greatly analogous to past findings, which revealed that foliar application of 10% moringa leaf extract on the jojoba plants considerably increased their height (Taha *et al*., 2015).

These results further exhibited that the bioactive elements contained in moringa leaf extract, including cytokinins, vitamins, and minerals, played a vital role in the enhancement of physiological responses. This eventually led to improving the utilization of nutrients by the cabbage plants. Moreover, the urea fertilizer played an effective and positive role in supporting the vegetative growth and, consequently, enhanced the efficiency of photosynthesis. Plant hormones may also help plants to flourish and mature by affecting their growth and development phases. Foliar application of diluted moringa leaf extract (1:32) significantly increased the plant height in various cereals (Culver *et al*., 2012; Biswas *et al*., 2016).

A beneficial impact directly appeared in the productivity figures, as the treatments emerged with the highest scores, with the overall head weight and yield considerably enhanced versus the control treatment. Foliar application of moringa extract (10 ml $L^{-1}$) and urea fertilizer (6 g $L^{-1}$) showed the maximum values of all growth and yield-related traits, proving to be the most effective combination, which was significantly better than all other treatments. Bashir *et al*. (2014) reported that moringa leaf extract application made the tomato plants grow taller, with more leaves and branches, and occur more productively (Table 5).

**Table 3.** Effect of foliar application of moringa leaf extract and urea on the growth traits of cabbage.

| Treatments | Stem length (cm) | | | | Plant height (cm) | | | | Stem diameter (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Moringa (ml $L^{-1}$) | Urea (g $L^{-1}$) | | | | | | | | | | | |
| | 0 | 4 | 6 | Means | 0 | 4 | 6 | Means | 0 | 4 | 6 | Means |
| 0 | 10.51 | 15.88 | 17.66 | 14.68 | 32.4 | 36.9 | 38.6 | 35.96 | 42.51 | 49.70 | 48.93 | 47.04 |
| 5 | 13.62 | 18.17 | 18.91 | 16.9 | 30.1 | 39.4 | 40.7 | 36.73 | 40.26 | 49.10 | 51.51 | 46.95 |
| 10 | 14.47 | 19.33 | 19.32 | 17.70 | 33.5 | 37.7 | 42.36 | 37.85 | 42.54 | 48.06 | 50.28 | 46.96 |
| Means | 12.86 | 17.79 | 18.63 | 16.42 | 33.4 | 39.53 | 40.5 | 36.7 | 46.55 | 48.89 | 50.24 | |

$LSD_{0.05}$ 0: 1.722, M: 3.760, U: 4.883, M × U: 6.976

**Table 4.** Effect of foliar application of moringa leaf extract and urea on the growth traits and chlorophyll content of cabbage.

| Treatments | Head circumference (cm) | | | | Chlorophyll (%) | | | | Petiole thickness (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Moringa (ml $L^{-1}$) | Urea (g $L^{-1}$) | | | | | | | | | | | |
| | 0 | 4 | 6 | Means | 0 | 4 | 6 | Means | 0 | 4 | 6 | Means |
| 0 | 60.81 | 68.39 | 68.48 | 65.89 | 60.46 | 66.28 | 69.10 | 65.28 | 1.906 | 3.580 | 2.993 | 2.082 |
| 5 | 63.43 | 66.92 | 68.69 | 66.34 | 62.98 | 67.26 | 68.30 | 66.18 | 2.553 | 3.550 | 3.930 | 2.050 |
| 10 | 65.06 | 68.28 | 67.13 | 66.82 | 62.30 | 70.65 | 69.51 | 67.48 | 2.956 | 3.593 | 3.990 | 3.51 |
| 3.6 | 3.57 | 2.4 | 66.31 | 68.97 | 68.12 | 61.91 | 66.35 | 68.1 | 67.86 | 63.1 | means | |

$LSD_{0.05}$ 0: 1.640, M: 3.640, U: 4.523, M × U: 6.746

**Table 5.** Effect of foliar application of moringa leaf extract and urea on the yield traits of cabbage.

| Treatments | Marketable head weight (kg) | | | | Number of marketable leaves | | | | Total non-marketable head weight (kg) | | | | Total yield ($t/h^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Moringa (ml $L^{-1}$) | Urea (g $L^{-1}$) | | | | | | | | | | | | | | | |
| | 0 | 4 | 6 | Means | 0 | 4 | 6 | Means | 0 | 4 | 6 | Means | 0 | 4 | 6 | Means |
| 0 | 1.3 | 2.4 | 2.93 | 2.2 | 20.3 | 23.0 | 24.5 | 22.6 | 1.4 | 2.9 | 3.22 | 2.5 | 3.11 | 4.82 | 5.51 | 4.4 |
| 5 | 2.0 | 2.4 | 3.00 | 2.4 | 24.8 | 25.7 | 27.3 | 25.9 | 2.09 | 2.52 | 2.58 | 2.3 | 3.42 | 5.71 | 6.57 | 5.2 |
| 10 | 2.1 | 2.5 | 2.90 | 2.5 | 24.4 | 26.0 | 26.6 | 25.6 | 2.1 | 2.40 | 2.95 | 2.4 | 3.90 | 5.71 | 7.14 | 5.5 |
| Means | 1.8 | 2.4 | 2.9 | 2.3 | 23.1 | 24.9 | 26.1 | 24.7 | 1.8 | 2.6 | 2.9 | 2.4 | 3.4 | 5.4 | 6.3 | |

$LSD_{0.05}$ 0: 1.448, M: 3.677, U: 4.985, M ×U: 6.974

The moringa leaf extract's antioxidants and natural plant hormones are proven to be effective in stimulating photosynthesis, cell division, and sustaining tissue growth, eventually promoting the growth and yield traits. From a practical perspective, these results suggested that integrating moringa leaf extract with nitrogen fertilization can considerably be one of the sustainable agricultural practices. The said treatment contributes to enhancing growth and productivity while reducing dependence on massive chemical fertilizers, thereby offering both environmental and economic benefits. Mvumi *et al*.'s (2013) findings showed that spraying diluted moringa extract on the leaves of maize and common beans made them taller.

The said improvement in cabbage plants could refer to the presence of zeatin (cytokinin) found in moringa leaf extract, which plays a pivotal role in enhancing growth-related traits. According to Fuglie (2000), moringa leaf extract contains sufficient amounts of growth-stimulating substances that accelerate cell division and their enlargement. Zeatin, in particular, promotes lateral bud growth, leading to an increased number of branches and leaves. By applying the moringa leaf extract on plant foliage, it extends the plant life while enhancing the roots, stems, and leaves' weight, eventually producing larger fruits with enhanced productivity (Foidle *et al*., 2001).

Additionally, past studies confirmed that zeatin in moringa leaf extract maintains larger leaf areas, boosting photosynthetic activity and chlorophyll content (Tetley and Thimann, 1974). Rady *et al*. (2015) further

highlighted that cytokinins enhanced the nutrient translocation to new growth areas, supported healthy plant development, and delayed the leaf senescence, thereby preserving larger leaf areas for photosynthesis. The application of moringa leaf extract has led to considerable improvements in growth and yield traits of onion, pepper, soybean, sorghum, coffee, tea, chili, melon, and maize (Fuglie, 2000). It also enhances metabolic and auxin activities, leading to improved plant growth and development, head weight, and head diameter (Meena and Paliwal, 2003).

## CONCLUSIONS

The relevant study underscores the potential of natural plant growth enhancers, such as moringa leaf extract, in promoting sustainable agriculture. Nitrogen fertilization also significantly contributes to the improved photosynthetic rates, resulting in an increased carbohydrate supply.

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