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# Assessment of Water and Nitrogen Productivity of Cabbage and Lettuce Planting Under Greenhouse

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## ABSTRACT

This experiment studied water and nitrogen productivity for cabbage and lettuce under the shortage of nitrogen and irrigation water during growing cabbage (Saturn) and lettuce (Babura) plants. Mass production, nitrogen productivity, water productivity, chlorophyll A, chlorophyll B and total chlorophyll ,respectively were test under using four levels of nitrogen fertilization (0, 50, 100 and 150% of Nitrogen recommended) and also four levels of water regime (50%, 75%, 100% and 125% of ETc) in Libya conditions. The optimum conditions in drip irrigation greenhouse for crops grow were provided to give us high yield, quality production for cabbage and lettuce crops. Applying 100% N fertilization and 125% ETc to cabbage was the highest nitrogen productivity of 1132.3 kg $_{yield}$ /kg $_{N}$, water productivity 17.32 kg/m$^3$ and mass production of 17.57 Mg/ha.The highest value of chlorophyll A, chlorophyll B and total chlorophyll obtained with 100%N and 100% ETc applied water for cabbage were (0.505, 0.753 and 1.258 mg/100gm) while for lettuce were (0.382, 0.299 and 0.681 mg/100 gm), respectively.

***Keywords:*** cabbage, lettuce, nitrogen, water, productivity.

## INTRODUCTION

Cabbage (Brassica oleracea) is found in crucifer family and very rich in antioxidants, protein, carbohydrates, amino acids, minerals and vitamins (Atanasova, 2008). Xu and Leskovar (2014) & Verma *et al.*, (2017) illustrated that the effect of water irrigation stress is clearly visible in cabbage leaves that decrease area and height, absorb light and photosynthetic. Lettuce (Lactuca sativa L.) consider very rich in minerals, carotenoids, chlorophylls, amino acids, antioxidants and carbohydrates and used widely to make fresh healthy salad as observed (Mou, 2009). Midan and Sorial (2011) showed lettuce one of the Asteraceae family's plants. Leaves of lettuce fight cancer because of phytochemicals and have a high content of vitamins C, vitamins A and antioxidants (Masarirambi *et al.*, 2012). Water using will raise in 2050 for achieving world food needs on water resources (De Fraiture and Wichelns, 2010) and (Velasco-Muñoz *et al.*, 2018).

Bhamoriya and Mathew (2014) found that adding 1.25% Ep was the maximum for lettuce crops and cabbage. Also, and its drip irrigation levels were (0.50, 0.75, 1.00 and 1.25 % Ep). Bista *et al.*, (2018) indicated that crops yield of lettuce and cabbage was low under minimum regime water, irrigation water level (100, 80 and 60% ETc) and depth of drip line were (5, 10, 15, and 20 cm) and yield decrease at surface treatments the best yield crop was for 10 cm depth. Dasgupta *et al.*, (2017) investigated that lettuce crops yield, and cabbage were diminished at the scarcity of nitrogen on another hand hyper fertilization with nitrogen cause late growth. Water irrigation losses values include water moving from (27-42%) in traditional irrigation methods determined by the soil properties (Agarwal and Khanna,1983). Provide water as drop after drop on the surface soil to the plant during growing based on plant age in a low-pressure drip irrigation system which decreases costs and water irrigation and got high quality of crop (Tiwari *et al.*, 1998). Hashem *et al.*, (2018) showed that there is minimum water applied which plants need and water stress by using drip irrigation which led to low water losses and percolation deeply. The high yield of lettuce and cabbage crop was of 150% ETc. in drip irrigation (Allen *et al.*, 1998).

There are a lot of agricultural problems in Libya such as high demand for vegetables, limitation of water and energy and lack of labor skills for planting in the greenhouse

The main objectives of this research were:

1)improvement the greenhouse productivity under drip irrigation.
2) detect optimum productivity for cabbage and lettuce crops
3) saving water and nitrogen fertilization

## MATERIALS AND METHODS

The research was conducted at the farm of the agricultural research station, Agricultural Research center, Tripoli, Libya (latitude of 32° 12` 25`` and longitude of 13° 62` 16``) during the winter season of 2021-2022. Cabbage and lettuce crops were planted in November 2021. The soil of the experimental study wasn't planted five years ago so the land was reclamation to preparing it for planting and then put drip irrigation system as illustrated in Fig. (1). Tables 1 and 2 show the different properties of the experimental soil. It is sandy soil. Cabbage (Saturn) and lettuce (Babura) plants was used in this research.

The distance between rows and plants on the same furrow was 100 and 30 cm respectively. A two-meter

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distance was left between different treatments to avoid overlapping between different treatments.

Different agricultural practices were performed as recommended. Irrigation water samples were collected as shown in Table 3 during the growing season and the electrical conductivity was measured every time within an average of 1.03 ds/m. Phosphorous and potassium fertilizers were applied in liquid form during irrigation. Phosphate and potassium fertilizer were added in the form of Phosphoric Acid $H_3PO_4$ 85%(w/v) and JOSPA K50. Nitrogen fertilizer was added in the form of nitrate (3.88 kg) and applied in four equal doses: The first one at 20 days after planting on 29/11/2021 after planting and the other on 29/12/2021 and the other on 9/1/2022.while the last dose from potassium only on 4/2/2022

Samples were taken from the soil field with dimensions of 23 × 30 = 690 $m^2$. The field experiment was divided into sixteen combinations treatments. Four irrigation schedules (50%, 75%, 100% and 125% ETc) and four nitrogen nutrient levels distributed (0, 50, 100 and 150%N).

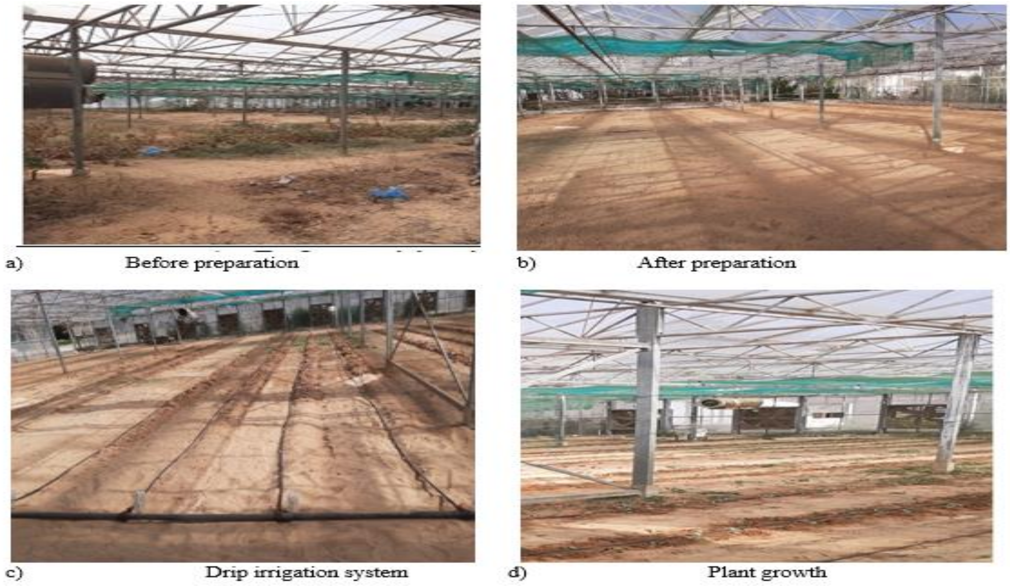


**Fig. 1. greenhouse preparation stages**

**Table 1. some physical properties of the soil study site**

| Mechanical soil analysis | | | | Water | wilting point | Field capacity | Total porosity | density | Depth |
|---|---|---|---|---|---|---|---|---|---|
| **Texture** | **Mud%** | **Celt %** | **Sand%** | **Facilitate%** | **%** | **%** | **%** | **gm/cm³** | **(cm)** |
| Sandy | 3 | 8 | 89 | 5.13 | 4.5 | 9.63 | 28% | 1.63 | 0 – 30 |

**Table 2. chemical analysis of soil experiment**

| Sulfates mEq/L | Bicarbonate mEq/L | Chloride mEq/L | Potassium mEq/L | Sodium mEq/L | Magnesium mEq/L | Calcium mEq/L | ( pH) | ( EC) Ds/m | Depth (cm) |
|---|---|---|---|---|---|---|---|---|---|
| 1.90 | 1.5 | 1.4 | 0.41 | 1.74 | 1.32 | 1.36 | 7.5 | 0.48 | 0 – 30 |

**Table 3. chemical analysis of irrigation water for the study site (MM McAfee/L)**

| Sulfates mEq/L | Bicarbonate mEq/L | Chloride mEq/L | Potassium mEq/L | Sodium mEq/L | Magnesium mEq/L | Calcium mEq/L | ( pH) | ( EC) Ds/m |
|---|---|---|---|---|---|---|---|---|
| 2.24 | 4.82 | 7.12 | 0.11 | 5.2 | 4.34 | 4.46 | 7.14 | 1.50 |

### The drip irrigation system.

The drip irrigation used was tested before the growing season. It consisted of a centrifugal pump operated by an electrical engine. The main line of 2.5" diameter is made from polythene. An irrigation system consists of 12 lines each line 20 meters long with 12 mm in diameter and has been installed with drippers at a pressure of 0.5 bar. each line is connected to the control valve for the quantity of irrigation water and is connected to a 32mm diameter branch line. Irrigation water requirements for the fixed drip irrigation system were calculated based on the meteorological data collected from Tripoli weather.

### Nitrogen productivity

Nitrogen productivity ($kg_{yield}$ / $kg_N$) was calculated as following (Ali *et al*., 2007)

$$NP = Y / N$$

**Y: mass production (Mg/ha)**

**N: total nitrogen fertilization ($kg_N$ / ha).**

### Water productivity (WP)

Water productivity (kg /$m^3$) was determined according to Rodrigues and Pereira, (2009) It referred to crop yield per unit of water applied (kg/$m^3$)

$$WP = Y / W$$

**Y: mass production (Mg/ha)**

**W: applied water ($m^3$/ha).**

### Chlorophyll a, chlorophyll b and total chlorophyll.

Chlorophyll was determined using Lichtenthaler and Welburn (1983) method by putting a Leaf sample in solvent and extracted using 20 ml of it for 24 h under dark conditioned. At wavelength 665 nm and 649 nm measuring chlorophyll a, chlorophyll b and total chlorophyll.

## RESULTS AND DISCUSSION

The mass production, Nitrogen productivity, Water productivity, chlorophyll A, chlorophyll B and total chlorophyll were tested for cabbage and lettuce crops at different levels of watering and nitrogen deficiency stress including: four watering levels of 50%, 75%, 100% and 125% ETc and four nitrogen fertilization rates of 0, 50, 100 and 150%N and different combinations of both watering and nitrogen levels were also used

**Irrigation and nitrogen deficiency with mass production**

The differences via watering and nitrogen regime levels affected of mass production for both cabbage and lettuce. The results are depicted in Fig. (2) showed moisture and nitrogen deficiency significantly influenced cabbage and lettuce mass production. Water shortage strongly reduced yield. The highest cabbage mass production was recorded at (125% ETc applied water and 100 kg Nitrogen) was 17.57 (Mg/ha) while the lowest was 11.85 Mg/ha at the treatment received (50%ETc watering regime and 0 kg nitrogen) whilst the minimum for lettuce was 4.45 Mg/ha for (125% ETc water regime and 150%N) while top value was 15.35 Mg/ha at 100% ETc and 100 kg N).

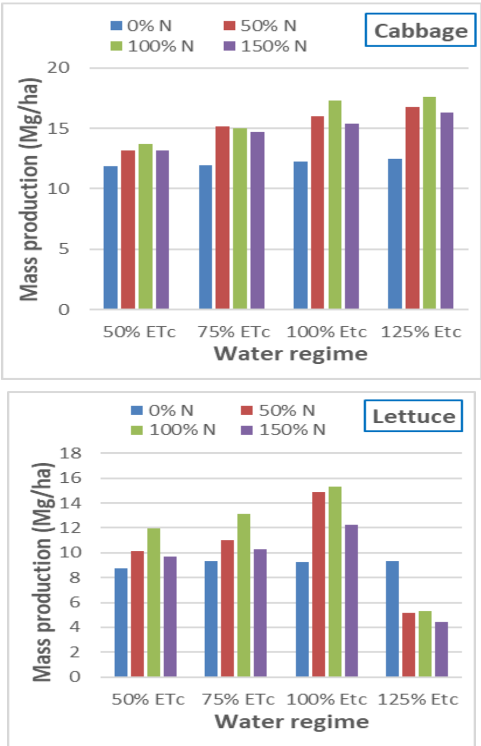


**Fig. 2. The relationship between water regime and mass production for cabbage and lettuce crops**

**Watering and nitrogen deficiency via nitrogen productivity**

The association between Nitrogen productivity for cabbage and lettuce crops was illustrated in Fig. (3). The results demonstrated cabbage nitrogen productivity was increased from 880.58 ($kg_{yield}$ / $kg_N$) at 50% ETc to 1132.3 ($kg_{yield}$ / $kg_N$) at 125% ETc at recommended nitrogen level. The lowest was 768.3 ($kg_{yield}$ / $kg_N$) using (75% ETc and without nitrogen).

lettuce Nitrogen productivity value was raised to 989.26 ($kg_{yield}$ / $kg_N$) using 100% ETc and nitrogen and then dropped. The minimum Nitrogen productivity was recorded with the treatment received the highest levels of watering regime and the greatest nitrogen fertilization rate 286.73 ($kg_{yield}$ / $kg_N$).

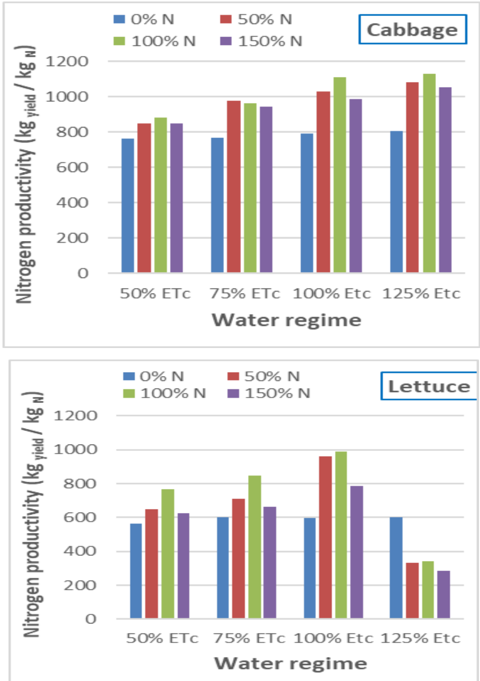


**Fig. 3. The relationship between water regime and nitrogen productivity for cabbage and lettuce crops**

**Affecting nitrogen levels and water shorting via water productivity**

For lettuce, the water productivity increased from (0 N% to recommended N%) at 50%, 75% and 100% ETc and then decreased on another hand the water productivity decreased from 0% nitrogen to 150% nitrogen at 125% ETc. The maximum value was 15.13 ($kg/m^3$) for lettuce while the minimum was 4.39 ($kg/m^3$). The highest water productivity for cabbage was 17.03 ($kg/m^3$) at water irrigation and nitrogen fertilization recommendation while the lowest was 11.68 ($kg/m^3$) without adding any nitrogen and using 50% ETc water applied as recorded in Fig. (4).

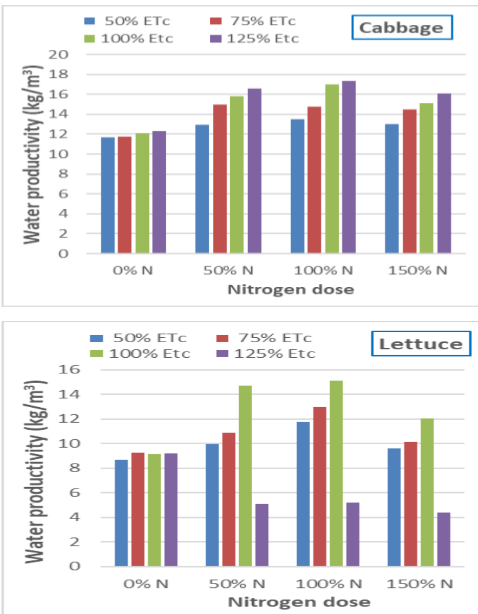


**Fig. 4. The relationship between nitrogen dose and water productivity for cabbage and lettuce crops**

**The effect of nitrogen deficiency and watering regime on chlorophyll A content**

Fig. (5) illustrated the chlorophyll A increased in cabbage crop up to 100% N and 100%ETc was 0.505 mg/100gm whilst the minimum was 0.079 mg/100gm at using 150% N and 100% ETc. In the lettuce crop the chlorophyll A content increased from 0.129 mg/100gm at zero% nitrogen and applied water 125% ETc to 0.382 mg/100gm for 100%ETc and 100%N fertilization.

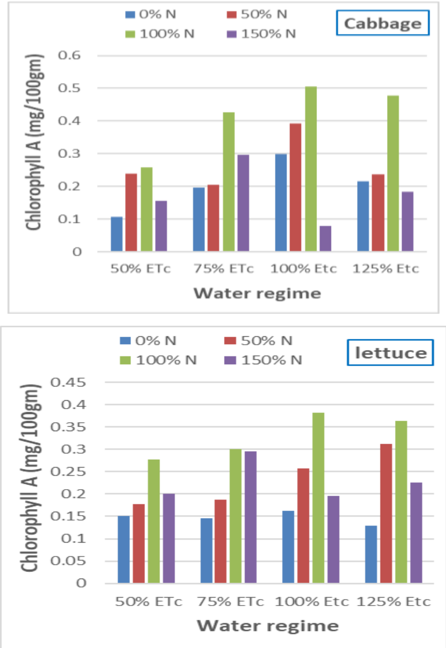


**Fig. 5. The relationship between water regime and total chlorophyll A for cabbage and lettuce crops**

**Watering and nitrogen fertilization shortage at chlorophyll B content**

At recommended dose for irrigation water for cabbage was the maximum chlorophyll B was 0.753 mg/100gm at applied 100% nitrogen while the minimum was 0.057 mg/100gm at adding 0% nitrogen and 100% ETc in fig (6).

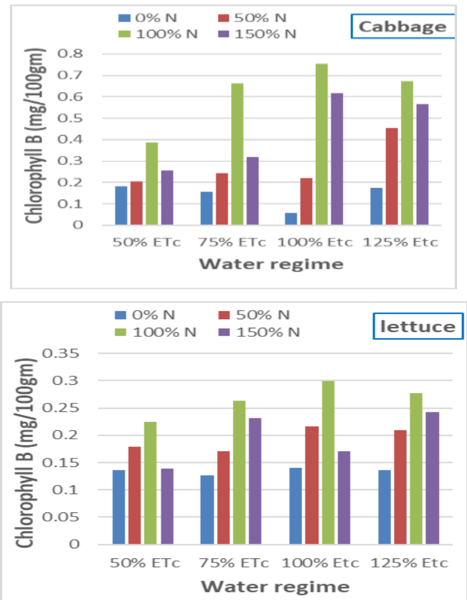


**Fig. 6. The relationship between water regime and chlorophyll B for cabbage and lettuce crops.**

For lettuce crops the lowest content of chlorophyll B at treatment (0% N and 50% and 125% ETc) was 0.136 mg/100gm although the raised value was 0.299 mg/100gm at 100%ETc and 100% nitrogen.

**The association between deficiency water and nitrogen levels on total chlorophyll**

Adding nitrogen fertilizer, it led to high content of total chlorophyll for cabbage up to 100% N and then the value become lower. The minimum value was 0.288 mg/100gm at using 50% ETc and 0%N whilst the high value for total chlorophyll was at 100% ETc + 100% N 1.258 mg/100gm.

For lettuce the results illustrated at recommended irrigation and nitrogen dose was the highest total chlorophyll 0.681 mg/100gm but the lowest was 0.265 mg/100gm at treatment 0% nitrogen and 125%ETc in fig. (7).

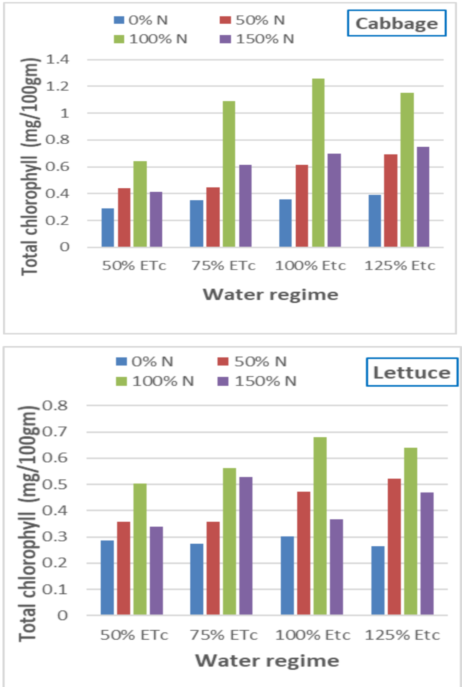


**Fig.7. The relationship between water regime and total chlorophyll for cabbage and lettuce crops**

## CONCLUSION

The obtained results were the cabbage and lettuce crops yield were highly affected by the deficiency of both nitrogen fertilization and water irrigation regime. The mass production, nitrogen productivity and water productivity had the opposite way as they increased with increasing the amount of irrigation level up to 100%ETc and then decreased at 125% ETc, also after adding 100% N the values dropped in lettuce.

At 100% N fertilizer for cabbage, the mass production decreased by 28.98% at dropped ETc from 100% to 50%. But the lettuce crop rate was 39.79%.

The highest chlorophyll A, chlorophyll B and total chlorophyll content for cabbage lettuce crop were obtained with 100% ETc watering regime and 100% nitrogen. cabbage and lettuce crops productivity can be maximized if the proper water regime and nitrogen fertilization rate are recommended.

## ACKNOWLEDGEMENT

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# تقييم انتاجية الماء والنتروجين لزراعة الكرنب والخس فى البيوت المحمية

**طارق فودة[1] ، نورى البى[2] ، الطاهر على[2] و شيماء صلاح[1]**

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## الملخص

تهدف الدراسة إلى تقليل مياه الرى وخفض مستوى التسميد النتروجينى مع تعظيم الإنتاجية والحفاظ على نوعية وانتاجية محصولى الكرنب والخس وأجريت التجربة تحت الظروف الليبية لنباتات الكرنب والخس وتم قياس الإنتاجية للمحصولين وإنتاجية النيتروجين وإنتاجية المياه والمحتوى من الكلوروفيل أ والكلوروفيل ب والكلوروفيل الكلي على التوالي باستخدام أربعة مستويات من التسميد بالنيتروجين. (٠ ، ٥٠ ، ١٠٠ و ١٥٠٪ نيتروجين) وأيضًا أربعة مستويات لكمية المياه (٥٠٪ ، ٧٥٪ ، ١٠٠٪ و ١٢٥٪ من الإحتياجات المائية للنبات). تم توفير الظروف المثلى للري بالتنقيط بداخل الصوبة الزراعية لزراعة المحاصيل لإعطائنا إنتاجية عالية وجودة الإنتاج لمحاصيل الكرنب والخس. أسفرت النتائج عن زيادة الإنتاجية للمحصول وإنتاجية النيتروجين وإنتاجية المياه بنسبة ٧١,٠٢٪ للخس باستخدام ١٠٠٪ من الإحتياجات المائية للمحصول و ١٠٠٪ نتروجين. انخفضت إنتاجية النيتروجين وإنتاجية المياه عند ٢٨,٩٨ و ٢٠,٨٨ ٪ على التوالي لمحصول الملفوف بينما كانت ٢٢,٢٨ ٪ للخس. انخفضت إنتاجية النيتروجين وإنتاجية المياه بنسبة 28.98 و 20.88 ٪ على التوالي لمحصول الكرنب بينماانخفضت بمعدل 22.28 ٪ للخس عند تطبيق التسميد عند مستوى ١٠٠٪ نيتروجين و ١٢٥٪ من الإحتياجات المائية للمحصول على محصول الكرنب كانت أعلى إنتاجية للنيتروجين ١١٣٢,٣ (كجم محصول / كجم نيتروجين) وإنتاجية المياه (١٧,٣٢ كجم / م ٣) والإنتاج الضخم (١٧,٥٧ ميجاجرام / هكتار). أعلى قيمة للكلوروفيل أ والكلوروفيل ب والكلوروفيل الكلي المتحصل عليه مع ١٠٠٪ نتروجين و ١٠٠٪ ETcمن الإحتياجات المائية لمحصول الكرنب كانت (٠,٥٠٥ و ٠,٧٥٣ و ١,٢٥٨ مجم / ١٠٠ جم) بينما كانت الخس (٠,٣٨٢ و ٠,٢٩٩ و ٠,٦٨١ مجم / ١٠٠ جم). )، على التوالى.

***الكلمات الدالة:*** الكرنب، الخس، النتروجين، الماء، الإنتاجية.