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Assessment of Broccoli (*Brassica oleracea*) Cultivation under Two Irrigation Systems in Central Iraq

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Abstract

A field experiment was conducted in the Abbasiya area of Najaf Governorate, located in the Middle Euphrates region during the winter season of 2022-2023. The primary focus of the study was to evaluate the performance of two irrigation systems, nano-irrigation, and subsurface drip irrigation, on broccoli plants grown in clay soil. The experimental design followed a Complete Randomized Block Design (CRBD). Nano-irrigation demonstrated several advantages over subsurface drip irrigation. It exhibited a reduction inater consumption and lower energy requirements for water pumping operations. Notably, the root length of broccoli plants was significantly greater under the nano-irrigation system, with an increase of 18.2 cm compared to the drip irrigation system. The use of nano-irrigation resulted in better water use efficiency and energy efficiency, leading to improved root development in the broccoli plants. The study results indicated that nano-irrigation offers benefits in terms of water conservation and plant growth promotion, ultimately leading to increased overall productivity. This makes nano-irrigation an appealing option for improving water use efficiency in agriculture, particularly in regions that face water scarcity. Moreover, there was no significant difference in yield between the nano-irrigation and subsurface drip irrigation systems.

Keywords: broccoli plant, irrigation, drip irrigation, nano-irrigation.

Introduction

Broccoli belongs to the Brassicaceae family and its scientific name is Brassica oleracea Var. italica is considered a winter vegetable. Broccoli is an annual herbaceous plant similar in morphology to cauliflower. It is one of the few widespread plants in Iraq and is ranked thirty-first in the world in terms of cultivation and production. It is considered one of the most important plants with high nutritional values from a medical standpoint because it contains many vitamins and mineral elements [1].

Therefore, the main objective of the study was to evaluate the effect of subsurface drip irrigation and nano-irrigation methods on broccoli crop production under Iraqi environmental conditions.Effective irrigation practices play a crucial role in

controlling and optimizing water use to achieve high yield per unit area, contributing to food security for humans and livestock[2]. In Iraq, the primary water resources are the Tigris and Euphrates rivers, with rainfall playing a secondary role in meeting water demands, particularly in agriculture. Groundwater resources rank third in importance due to their limited availability[3]. Drip irrigation is a well-known irrigation system that delivers water directly to the soil in small droplets, approaching the field capacity, and targeting the root area. Subsurface drip irrigation, on the other hand, involves irrigating the root zone while also controlling the groundwater level. The depth at which the drip lines are buried is determined based on factors such as crop type, soil characteristics, water source, climate conditions, and tillage techniques [4]

Nanotechnology irrigation, a novel technique, operates by releasing a small amount of water at a rate similar to the rate at which plant roots absorb water from the soil. Nano-irrigation differs from traditional irrigation methods in that water is emitted along a nanomembrane in all directions, unlike the directional flow of water in subsurface drip tubes[5]. Therefore, the study aimed to compare the water consumption, energy requirements, and root development of the plants under both irrigation methods. Additionally, the research sought to determine if nano-irrigation could improve water use efficiency, promote plant growth, and increase overall productivity, particularly in water-scarce regions. The study also aimed to evaluate the potential yield differences between nano-irrigation and subsurface drip irrigation systems.

Materials and Methods

The field experiment was conducted in one of the fields within the Abbasiya region, located in the Middle Euphrates region of the Najaf Governorate, which is located at latitude and longitude 44.43 and 32.07 and at an altitude of 31 m above sea level during the winter season of 2022-2023. The experiment was carried out according to the design. The experiment was designed according to Randomized complete block design, known as (RCBD), with two treatments of nano-irrigation and sub-surface drip irrigation, with three replications, and each strip is irrigated with three irrigation lines, the length of one line (25 metres) and the distance between the lines (1.5 metres), where one line is divided into four panels, the length of one panel) 5 meters) and between one panel and another there is a distance of (1) meter, so the total number of units reached (24 experimental units). The irrigation networks are supplied with water from two tanks with a capacity of 1000 liters each. These two tanks are at a height of 2 meters and are connected to each other, and a main pipe with a diameter of 19 mm branches from them, which is distributed to the irrigation networks SDI and NTI with a pipe with a diameter of 12.5 mm connected to a water drainage meter device and equipped with a valve to regulate the water drainage in each. sector, and the water moves from the two tanks due to the force of Earth’s gravity. The broccoli variety is planted during the month of October 2022. The seeds of this variety are Dutch produced. The seeds were planted

In cork dishes filled with peat moss, one seed per bowl. After a month of planting, on November 27, 2022, the plants were transferred to the field and planted in lines on both sides of the branch lines, at a rate of 20 seedlings per pad.

The studied properties included field water use efficiency (WUEf) and various growth characteristics and yield components:

Field Water Use Efficiency (WUEf):

Field water utilization efficiency was calculated using the equation proposed by [6]WUEf = Yield / Water applied

Where: WUEf = Field water utilization efficiency (kg-m), Yield = Total yield (kg), Water applied = Amount of irrigation water added (m^{-3}).

Measurement Of Growth Characteristics and Yield Components:

2.1. Yield per Plant:

The weight of the plant was measured within the experimental units, and the result was converted based on the unit area.

2.2. Total Root Length:

The root Plants were uprooted from each experimental unit, then taken and the roots were washed with a calm, continuous stream of water.To maintain the integrity of the roots, the length of the main roots was then measured with a metric tape and the average root length was extracted.Results and discussion

1-Water Efficiency Comparison Between NTI and SDI Irrigation Systems

The study revealed a significant difference in the efficiency of water use between the nano-irrigation (NTI) and subsurface drip irrigation (SDI) systems. The water use efficiency in the NTI system was found to be 13.90 kg m^{-3}, whereas in the SDI system, it was only 2.45 kg m^{-3} (as shown in Figure 1). This stark contrast indicates that the NTI system consumes significantly less water while achieving higher output compared to the SDI system. The water use efficiency of the NTI system was nearly six times greater than that of the SDI system. This result was consistent with numerous studies conducted in various regions of the world, including[7,8 ,9]. These studies have consistently demonstrated the superior water efficiency of NTI over SDI. Notably, the NTI system's advantage lies in its ability to minimize water consumption and reduce energy requirements during water pumping operations. This makes it an environmentally friendly and cost-effective irrigation option. The results of this study further support the potential of NTI as a water-efficient irrigation method for agricultural practices.

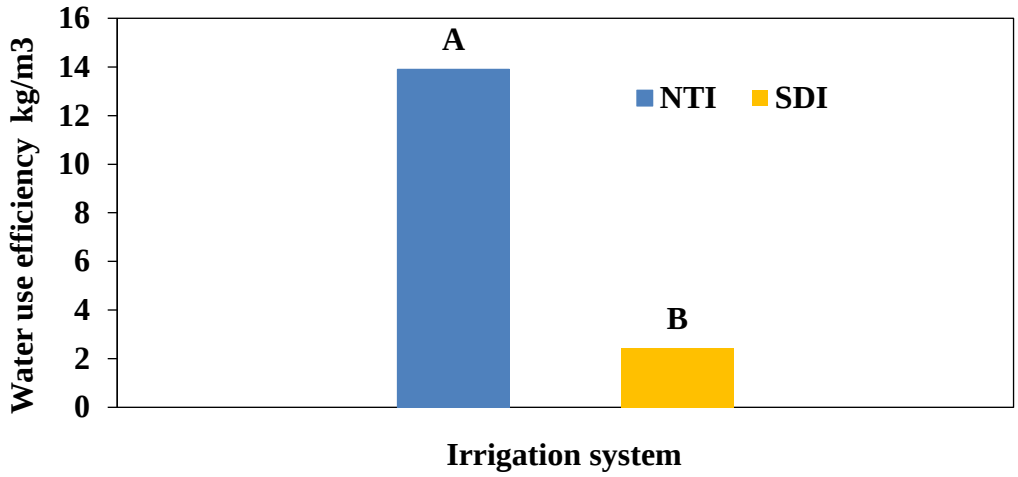

Figure (1): Water use efficiency in nan irrigation and subsurface drip irrigation

2-The Impact of Irrigation Type on Root Lengths of Broccoli Plants

The statistical analysis revealed a significant difference in the root lengths of broccoli plants between the nano-irrigation and subsurface drip irrigation methods ($F(13,27) = 91.79$, p-value = 0.0000). Nano-irrigation had a notable influence on the root system, with an average root length of 18.2 cm compared to an average root length of 91.79 cm in the drip irrigation method. These results indicated a significant disparity in root lengths between the nano-irrigation and subsurface drip irrigation methods for broccoli plants.

The utilization of nano-irrigation resulted in a significant increase in the length of the root system compared to the subsurface drip irrigation method. The average total root length in the nano-irrigation method measured 19.68 cm, whereas it was less than 12.3 cm in the drip irrigation method. These findings agreed with the research suggesting that nano-irrigation significantly influences root growth in vegetative plants. Nano-irrigation can positively impact water and nutrient availability in the soil, thereby promoting enhanced plant root development [10].

It is important to note that these results specifically pertain to the conditions of this study, focusing on the broccoli plant. This experiment marked the first application of such techniques in Iraq, particularly on the broccoli plant, which hold significant nutritional and medicinal value [11].

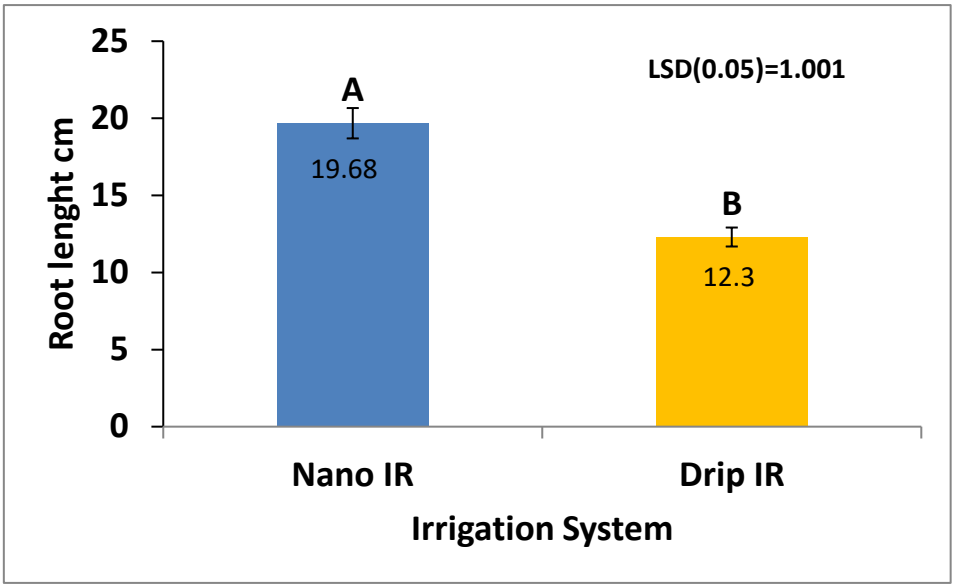

Figure (2) :Demonstrating the impact of nano-irrigation and drip irrigation techniques on the average root lengths of broccoli plants.

3-Yield

The statistical analysis results indicated that there was no significant difference in yield between the nano-irrigation and subsurface drip irrigation methods for broccoli plants, *p*-value = 0.718, and the F-value = 0.13. These values suggested that there was insufficient evidence to conclude that there are statistically significant discrepancies in the yield of broccoli between the two irrigation methods. The absence of a significant difference in yield can be attributed to various factors, including the study design. It is possible that certain factors not accounted for in the study design, such as variations in growing conditions, soil characteristics, and other environmental factors, may have influenced the yield of broccoli. It is important to acknowledge that these specific results may vary with future data or additional studies. Hence, further research and analysis are necessary to determine the factors that impact the harvest yield of broccoli or other crops when comparing nano-irrigation and subsurface drip irrigation without adding fertilizers.

Moreover, it is worth mentioning that research in this particular area may be limited in Iraq and globally when it comes to comparing the two irrigation systems without the use of fertilizers or fertilizer supplements. However, a study conducted by [12]in Saudi Arabia examined the effect of surface drip irrigation and subsurface drip irrigation on tomato plant growth. This study reported that subsurface drip irrigation had a more pronounced impact compared to surface drip irrigation.

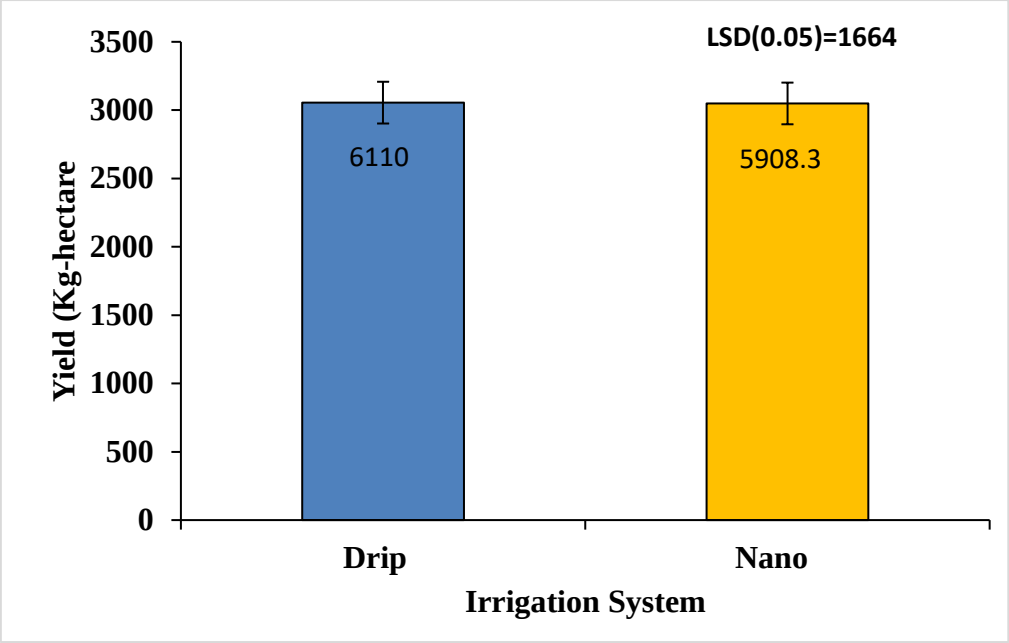

Figure (3): illustrates the yield of broccoli comparison between nano-irrigation and subsurface drip irrigation.

The amount of water consumed in the NTI irrigation system was much less compared to the SDI irrigation system. The nano-irrigation system consumed much less water and achieved higher productivity compared to the subsurface drip irrigation system. The nano-irrigation method showed a significant effect in increasing the length of the root system and the greater growth of plant roots compared to the drip irrigation method. There was no significant difference between the amount of yield produced in nano-irrigation compared to subsurface drip irrigation.

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