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Mustafa Abdul Ameer Kahtan
Agricultural Extension and Training Officer, Ministry of Agriculture, Iraq

Israa Adnan Al-Malaky
Agricultural Extension and Training Officer, Ministry of Agriculture, Iraq

Hayder Abdulaali Abdulhusein
Agricultural Extension and Training Officer, Ministry of Agriculture, Iraq

Anfal Sadq Faker
Agricultural Extension and Training Officer, Ministry of Agriculture, Iraq

Aala AdnanYousif
Southern Technical University, Ministry of Higher Education and Scientific Research, Iraq

Corresponding Author:
Mustafa Abdul Ameer Kahtan
Agricultural Extension and Training Officer, Ministry of Agriculture, Iraq

The effect of modern irrigation techniques on wheat growth and yield

Mustafa Abdul Ameer Kahtan, Israa Adnan Al-Malaky, Hayder Abdulaali Abdulhusein, Anfal Sadq Faker and Aala AdnanYousif

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Abstract
A field experiment was conducted in Al-Burjessia farms and the Al-Burjessia Demonstration Farm affiliated with the Agricultural Extension and Training Department / Ministry of Agriculture, located 65 km from Basra city, during the 2024/2025 season. The region is classified physiographically as desert (Buringh, 1960) and climatically as arid. The soil is categorized as Typic Quartzipsamment. The study aimed to assess the impact of irrigation techniques on wheat (*Triticum aestivum* L.) yield. Wheat seeds (variety: Bohouth 22) were sown using surface irrigation and drip irrigation systems. The experimental design followed a strip plot layout. Irrigation water quantity was calculated based on a root depth of 0-20 cm and 0-40 cm, restoring soil moisture to field capacity. Results showed that irrigation methods significantly affected growth parameters and grain yield, with drip irrigation producing the highest wheat yield.

Keywords: Wheat growth, yield, desert

Introduction
Water management refers to controlling and utilizing water to produce food and forage in an optimal manner while integrating natural, chemical, biological, and social resources to meet crop water requirements without harming the environment. Designing irrigation projects, including network capacity and irrigation methods, is crucial especially in areas with limited water resources, such as arid and semi-arid regions (Al-Akidi, 2018) [2].
Water is essential for plant growth. Its availability can be controlled, particularly in dry regions, by irrigation scheduling, which defines the amount and timing of water application. Irrigation also aims to manage saline water and reduce salt concentration in the root zone, enhancing plant growth by maintaining salt balance—closely linked to water quality, irrigation practices, climate, and soil properties (Emdad & Raine, 2014) [6].
Drip irrigation is considered the most efficient method, potentially increasing yields by up to 100% and saving 40-80% of water. It also improves water and nutrient use efficiency and reduces the need for labor, fertilizers, and pesticides (Lodhi *et al*., 2014; Kumari *et al*., 2014) [11, 8]. Drip irrigation can prevent runoff, deep percolation, and evaporation (Liu *et al*., 2021) [10].
Wheat (*Triticum aestivum* L.) is a strategic cereal crop in Iraq. Although the country has favorable conditions, wheat productivity remains below potential. In 2024, Iraq produced 5.234 million tons of wheat on 8.177 million hectares (Agricultural Statistics Directorate, Ministry of Planning, 2024).

Materials and Methods
The experiment was conducted during the 2024/2025 winter season in Al-Burjessia, Basra. Initial soil properties are presented in Table 1.
Land Preparation: The land was plowed twice perpendicularly, leveled, and divided into 2x2 m plots with 0.5 m spacing. Five planting rows were made per plot using 120 kg/ha of wheat seeds (Bohouth 22). Surface irrigation setup included main, sub-main, and feeder pipes; a drip system was installed on the second part of the field. Mixed irrigation water from the farm’s desalination unit and well was used as needed. Fertilizers were applied evenly along planting rows:

- Urea (46% N) at 125 kg N/ha in three splits (sowing, 1 month, and 2 months after sowing).
- Potassium sulfate (43% K) at 100 kg/ha (10% at sowing, the rest at flowering).
- Super phosphate (20.21% P2O5) at 120 kg P2O5/ha at sowing.

Seeds were sown on 15/11/2024.

Table 1: Chemical and Physical Properties of the Soil (0-30 cm Depth)

Property	Unit	Value
pH	-	7.40
EC	dS/m	5.68
Calcium carbonate	g/kg	128.2
CEC	Cmol/kg	5.52
OM	g/kg	0.93
Ca++	mmol/L	18.0
Mg++	mmol/L	20.1
Na+	mmol/L	5.9
K+	mmol/L	0.92
HCO3-	mmol/L	0.62
SO4=	mmol/L	18.5
Cl-	mmol/L	49.0
CO3=	mmol/L	0.0
Sand	g/kg	769.4
Silt	g/kg	142.9
Clay	g/kg	68.93

Plant Analysis and Growth Measurements

Flag leaves were collected from 10 randomly selected plants per plot at flowering, washed, dried at 65°C, ground, and analyzed using the wet digestion method (Cresser & Parsons, 1979).

- **Total Nitrogen:** Steam distilled after adding NaOH (10 N), per Bremner (1970) [21].
- **Total Phosphorus:** Extracted using 0.5 M NaHCO3 (pH 8.5), color developed with ammonium molybdate and ascorbic acid, measured by spectrophotometer at 882 nm (Olsen in Page *et al.*, 1982) [22].
- **Total Sulfur:** Determined by turbidity using BaCl2 and gum acacia (Page *et al.*, 1982) [23].
- **Total Potassium:** Measured using a flame photometer (Page *et al.*, 1982) [23].

Growth Parameters: Ten plants per plot were used to measure:

- **Flag leaf area (cm2)**: LSA = L x W x 0.75 (Thomas, 1975).
- **Dry biomass**: Plants harvested at soil level, dried at 65°C to constant weight, and converted to kg/ha.
- **1000-grain weight**: Seeds from 0.5 x 0.5 m area were collected and weighed.
- **Grain yield**: Calculated from 0.5 x 0.5 m area and expressed in Mg/ha.

Statistical Analysis

The experiment followed a randomized complete block design (RCBD) with factorial arrangement. Data were analyzed using GenStat, and means were compared using RLSD in Excel (Al-Rawi & Khalafallah, 1980) [24].

Results and Discussion

- **Nitrogen concentration in wheat leaves:** Drip irrigation significantly increased nitrogen concentration by 21.49% compared to surface irrigation ($p \leq 0.05$), likely due to improved water use efficiency and root nutrient uptake (Yang *et al.*, 2020; Dessie *et al.*, 2024) [18, 5].
- **Phosphorus concentration:** Drip irrigation also increased phosphorus concentration by 52.97% over surface irrigation ($p \leq 0.05$), attributed to enhanced moisture and phosphorus mobility in the root zone (Chtouki *et al.*, 2024) [13].
- **Potassium concentration:** Drip irrigation improved potassium uptake by 21.29%, likely due to better soil aeration and root access (Rajiv *et al.*, 2024) [20].
- **Sulfur concentration:** Drip irrigation yielded higher sulfur content (3.43 g/kg vs. 3.00 g/kg) through direct delivery of sulfur-containing fertilizers to the root zone (Aujla *et al.*, 2007; Yang *et al.*, 2023) [12, 17].

Table 2: Effect of Irrigation Method on Nutrient Concentration in Wheat

Irrigation Method	Nitrogen (g/kg)	Phosphorus (g/kg)	Potassium (g/kg)	Sulfur (g/kg)
Surface	17.03	1.85	20.33	3.00
Drip	20.69	2.83	24.66	3.43

- **Flag leaf area:** Drip irrigation increased leaf area by 43.17%, attributed to improved moisture, nutrient availability, and photosynthetic activity (Wang *et al.*, 2024; Singh *et al.*, 2023) [19].
- **Dry biomass:** Plants under drip irrigation produced more dry biomass (712 vs. 547 kg/ha) due to enhanced root growth and reduced water loss (Si *et al.*, 2023; Impa *et al.*, 2019) [15, 7].
- **1000-grain weight:** Drip irrigation resulted in heavier grains (60.03 vs. 52.20 g), linked to consistent moisture and nutrient uptake (Yu *et al.*, 2024; Lei *et al.*, 2022) [9, 19].
- **Grain yield:** Drip irrigation improved total yield by 35.98% over surface irrigation, aligning with results from Liu *et al.* (2021) [10].

Table 3: Effect of Irrigation Method on Growth Parameters and Yield

Irrigation Method	Leaf Area (cm2)	Dry Biomass (kg/ha)	1000-Grain Weight (g)	Grain Yield (Mg/ha)
Surface	19.11	547.00	52.20	3.64
Drip	27.36	712.00	60.03	4.95

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