Study of some growth traits in maize as a result of soil texture and depletion levels"

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Abstract

An experiment took place on an agricultural field in the Musayyib district of Babil Governorate, Iraq, in the fall of 2023. The study used a Randomized Complete Block Design (RCBD) with 24 treatments (four soil textures, replications and two levels of water depletion). soil textures included sandy, loamy, sandy loam, and silty loam, with water depletion levels set at 75% (I1) and 50% (I2). The purpose was to investigate how these variables affected specific maize traits. Treatment I2 (50% water depletion) had in a significantly larger stem diameter than I1 (75% water depletion). (T4) treatment produced the optimum stem development circumstances, with an average mean diameter of 3.05 cm. Under I2 treatment, the (T1) treatment had the largest stem diameter of 3.90 cm. The dry weight of the dried mass also differed significantly, with 11.56 g at 50% depletion (I2) 11.05 g at 75% depletion (I1). The (T3) treatment had the maximum dried mass at 12.787 g, whereas the (T2) treatment had the lowest weight of 8.883 g. Furthermore, stem height grew to 211 cm under 50% depletion (I2), up from 193 cm under 75% depletion (I1). The (T3) had the highest stem height of 236 cm among all soil texture classes. At 50% depletion (I2), leaf area increased to 4534 cm², up from 4408 cm² at 75% depletion (I1). The (T3) treatment had the highest leaf area of 5046 cm².

Maize ears length to 19 cm at 50% depletion (I2), up from 17 cm at 75% depletion (I1). The (T3) treatment had the longest maize ear length (22 cm). There were no significant changes in the quantity of maize ears per plant between treatments, with a mean of 2 maize ears/plant regardless of depletion amount or soil texture. This experiment proves the possibility of enhancing water resource management in agriculture in order to increase crop productivity, so contributing to food security and sustainability.

Key words: Zea mays, soil texture, irrigation, water depletion, corn ears

Introduction

Using water wisely and promising that crops may be grown sustainably in agriculture depend on appropriate irrigation controlling. Plant growth and yield are greatly impacted by irrigation depletion, the term for the drop in soil moisture brought on by plant absorption and evaporation [1]. Farmers can guarantee crops have enough water, which will increase the quantity and quality of their growth, by managing irrigation depletion levels. Studying these effects in detail is fundamental to creating the most favourable irrigation plans since varying degrees of depletion level might impact different facets of plant growth [2.[

The way that soil stores water and provides nutrients to plants depends in large part on its texture. The physical qualities of various soil textures—sandy, loamy, sandy loam, and silty loam, for example—affect how effectively they promote crop growth [3].For example,

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silty loam soils hold water, but sandy soils have bigger particles. Managing soil well and raising crop yields require an understanding of how soil texture interacts with irrigation techniques.

Maize, sometimes referred to as corn, is a major crop with great significance in agriculture and economy all over the world. Because of its great sensitivity to soil and water conditions, it is a great crop to research irrigation and soil management. Water availability and soil texture have a direct effect on maize stem diameter, dried mass, stem height, leaf area, and ear length among other parameters [4]. Through analysis of these elements, important knowledge can be obtained to improve maize farming methods [5.[

The purpose of this study was to find out how particular properties of Zea mays produced in the Musayyib area of the Babil Governorate, Iraq, are impacted by depletion level and soil textures.

Material and methods

The experiment was conducted in an agricultural area in the Al-Musayyib district of Babylon Governorate in 2023. The experiment covered a 200 square meter area and involved excavating two trenches, each measuring 7.5 meters long and 0.5 meters wide. Sixteen plastic barrels were placed in one trench, while eight were positioned in the other, in total 24 lysimeters across three replicates.

Four different soil textures sandy, loamy, sandy loam, and silty loam—were placed in 24 plastic barrels, each 1 meter tall and 0.29 meters in diameter. Drainage taps were fitted at the base of each barrel to regulate water outflow, and fine gravel was placed to prevent soil erosion. Physical and chemical properties of soil textures T1, T2, T3, and T4 were analysed before maize cultivation (Table 1.(

Hybrid corn seeds (Babylon variety) were planted 0.02 meters deep in each barrel.

The experiment was factorial and arranged in a randomized complete block design (RCBD) with 24 treatment combinations, including two irrigation levels—75% (I1) and 50% (I2) of available water—and four soil textures, each replicated three times. Statistical analysis was performed using the Statistix version 10 software (https://www.statistix.com), and the data were subjected to analysis of variance (ANOVA). The Least Significant Difference (LSD) test was conducted at a significance level of 5% ($P < 0.05$) to identify significant differences between treatment means.

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Table (1). Physical and chemical properties of soil textures T1, T2, T3, and T4 before maize cultivation

Character	Unit	T1	T2	T3	T4
Physical Properties					
Sand (%)	-	86.54	92.66	64.1	39.62
Silt (%)	-	10.2	4.08	32.64	57.12
Clay (%)	-	3.26	3.26	3.26	3.26
Soil Texture	-	Loamy Sand	Sand	Sandy Loam	Silty Loam
Bulk Density	$Mg.m^3$	1.65	1.49	1.26	1.27
Particle Density	$Mg.m^3$	2.64	2.51	2.42	2.64
Total Porosity	%	0.37	0.3	0.47	0.51
Volumetric Water Content at 33 kPa	cm^3 cm^3	0.26	0.25	0.3	0.35
Volumetric Water Content at 1500 kPa	cm3 cm^3	0.09	0.08	0.1	0.15
Available Water	cm3 cm3	0.17	0.17	0.2	0.2
Saturated Hydraulic Conductivity	cm.hr1	10.9	38.4	5.2	4.1
Chemical Properties	**Unit**	**T1**	**T2**	**T3**	**T4**
Soil Salinity (ECe)	dS/m^{-1}	1.8	2.1	106	2.8
Soil pH	-	7.9	8.09	7.63	7.77
Organic Matter	$g.kg^1$	2.66	Nill	Nill	Nill
Calcium	$mmol/L^{-1}$	261	321	240	281
Magnesium	$mmol/L^{-1}$	182	219	97	170
Sodium	$mmol/L^{-1}$	24	78	68	170
Potassium	$mmol/L^{-1}$	7.6	10.6	17.1	12.1
Sulfate	$mmol/L^{-1}$	457	582	385	539
Chloride	$mmol/L^{-1}$	440	294	929	538
Bicarbonate	$mmol/L^{-1}$	244	85	244	146
Available Phosphorus	$Mg.kg^{-1}$	122	-	-	-
Total Nitrogen	%	-	-	-	-
Cation Exchange Capacity (CEC)	$c.mol/kg^{-1}$	-	-	-	-
Sodium Adsorption Ratio (SAR)	$(mmol/L^{-1})^{1/2}$	-	-	-	-

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Results and Discussion

.1 Stem Diameter (cm(

Table (2) shows that depletion levels cause considerable changes in stem diameter for maize plants. Treatment I2 (50% depletion) shows a substantial increase over I1 (75% depletion) because less depletion equals more water for plants, boosting tissue growth and stem diameter. Table (2) also shows stem diameter variations dependent on soil texture. Silt Loam soil (T4) had the largest stem diameter (3.05 cm) due to its capacity to properly hold and drain water, creating ideal circumstances for plant growth. Other soils, such as loamy sand (T1) and sandy loam (T3) demonstrated reduced water retention, resulting in slower growth rates. Table (2) shows how the relationship between depletion level and soil texture affects stem diameter. The maximum stem diameter (3.90 cm) was observed with a 50% depletion rate (I2) in loamy sand soil (T1), suggesting optimal conditions for plant development. In contrast, the smallest stem diameter was recorded at 75% depletion for I1 in the same soil texture, emphasizing the fundamental role of lower depletion rates in promoting plant growth. This result shows up the importance of sufficient water availability for enhancing photosynthesis and growth rates. Studies have shown that maintaining higher soil moisture levels can improve nutrient uptake, photosynthetic efficiency, and overall plant vigor (8). Therefore, reducing water depletion significantly contributes to improved plant development by ensuring sufficient water availability for critical physiological processes. Water facilitates plant growth by transferring nutrients and controlling temperature [6]. Soil texture influences water retention and nutrient availability, with Silt Loam soil being optimal because of its high retention and ventilation. Soils with good drainage may be ideal for continuous water supply. These outcomes were agreed with Huang, Ma [2.[

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Table (2) Impact of depletion levels (I1 = 75%, I2 = 50%) and soil texture types (sandy loam, loamy sand, silty loam) as well as their interaction on stem diameter (cm.(

INDEPENDENT VARIABLE	DEPENDENT VARIABLE	GROUPING	LSD VALUE
DEPLETION LEVEL	**Stem Diameter**		
I2	3.60	A	0.11
I1	1.85	B	
SOIL TEXTURE	**Stem Diameter**	**Grouping**	**LSD Value**
T4	3.05	A	0.15
T1	2.70	B	
T2	2.65	BC	
T3	2.50	C	
DEPLETION LEVEL AND SOIL TEXTURE INTERACTION	**Stem Diameter**	**Groups**	**LSD Value**
I2 T1	3.90	A	0.21
I2 T4	3.80	A	
I2 T2	3.40	B	
I2 T3	3.30	B	
I1 T4	2.30	C	
I1 T2	1.90	D	
I1 T3	1.70	DE	
I1 T1	1.50	E	

.2 Dried biomass weight (g(

Table (3) notable differences in how depletion levels affect the average weight of dried biomass. For instance, treatment I1 (75% depletion) resulted in a weight of 11.05 g, while treatment I2 (50% depletion) led to 11.56 g. These variations suggest that reducing water depletion to 50% (I2) increased the dry weight of the dried biomass compared to the higher depletion rate of 75% (I1), offering more water for plant growth.

In table (3), significant differences were observed in the impact of soil texture types on dried biomass weight. The dry weight ranged from 12.79 g for T3 to 8.88 g for T2. This indicates that sandy loam soil (T3) supported better dried biomass growth than sandy soil (T2), likely due to its superior balance of aeration and water retention, providing an optimal environment for plant growth.

Conversely, sandy soil, despite good aeration, suffers from poor water retention, limiting water availability for plants. Table (3) also shows notable differences in the interaction effect between depletion level and soil texture on dried biomass weight. Interaction treatment I2 T3 had the highest weight at 13.05 g, while treatment I1 T2 had the lowest at 8.40 g. Overall, a 50% depletion rate (I2) enhanced

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dried biomass weight regardless of soil texture, particularly evident in sandy loam soil (T3) and loamy sand soil (T1). This supports the hypothesis that soils with favorable physical properties of aeration and water retention benefit more from water provision [7]. Conversely, sandy soil (T2) exhibited the least dried growth under all depletion scenarios, underscoring the role of soil texture in interacting with water provision for optimal dried growth

Table (3) Impact of depletion levels (I1 = 75%, I2 = 50%) and soil texture types (sandy loam, loamy sand, silty loam) as well as their interaction on dried biomass weight (g.(

-3Plant height (cm(

INDEPENDENT VARIABLE	DEPENDENT VARIABLE	GROUPING	LSD VALUE
DEPLETION LEVEL	**Dried biomass weight (g)**		
I2	11.56	A	0.47
I1	11.05	B	
SOIL TEXTURE	**Dried biomass weight (g)**	**Grouping**	**LSD Value**
T3	12.79	A	0.68
T1	12.35	A	
T4	11.20	B	
T2	8.88	C	
DEPLETION LEVEL AND SOIL TEXTURE INTERACTION	**Dried biomass weight (g)**	**Groups**	**LSD Value**
I2 T3	13.05	A	0.10
I1 T3	12.53	A	
I2 T1	12.50	A	
I1 T1	12.20	AB	
I2 T4	11.33	BC	
I1 T4	11.06	C	
I2 T2	9.37	D	
I1 T2	8.40	E	

Table (4) shows considerable differences in the impact of water depletion on stem height. In treatment I1 (75% depletion), stem height arrived 193 cm, whereas in treatment I2 (50% depletion) the stem height reached 211 cm, implying that 50% water depletion (I2) resulted in a higher stem height than 75% depletion (I1). That was because increased water availability for efficient photosynthesis and growth .

Table also (4) showed significant differences in the influence of soil texture on stem height. the treatment T3 (sandy loam) had the highest stem height (236 cm), then, T1 (loamy sand)

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with approximately 221 cm, T4 (silty loam) with 195 cm, and T2 (sandy) with 156 cm, indicating that sandy loam (T3) provides the most favorable conditions for plant growth, followed by loamy sand (T1), loam (T4), and sandy soil (T2 .(

There were a significant differences in the interaction effect between water depletion level and soil texture, with the highest mean stem height observed in treatment I2 T3 reaching 245 cm, while the stem height in I1 T3 treatment was about 226 cm, in I2 T1 was 225 cm, I1 T1 was 216 cm, I2 T4 was 210 cm, I1 T4 had 180 cm, I2 T2 had 163 cm, and I1 T2 had 149 cm, highlighting optimal stem growth with the interaction of 50% water depletion (I2) and sandy loam soil)

,(with the cm. The outcomes suggest that adopting sandy loam soil to decrease water depletion promotes better plant growth. These outcomes were consistent with the study of Huang, Zhao [8], which emphasized the essential function of soil water availability in affecting stem height in maize plants, emphasizing its value as a growth-indorsing factor

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Table (4) Impact of depletion levels (I1 = 75%, I2 = 50%) and soil texture types (sandy loam, loamy sand, silty loam) as well as their interaction on plant] height (cm.(

.4Leaf area (cm2(

INDEPENDENT VARIABLE	DEPENDENT VARIABLE	GROUPING	LSD VALUE
DEPLETION LEVEL	**Stem height (cm)**		
I1	204	A	4.00
I2	200	B	
SOIL TEXTURE	**Stem height (cm)**	**Grouping**	**LSD Value**
T3	236	A	5.67
T1	221	B	
T4	195	C	
T2	156	D	
DEPLETION LEVEL AND SOIL TEXTURE INTERACTION	**Stem height (cm)**	**Groups**	**LSD Value**
I2 T3	245	A	8.02
I1 T3	226	B	
I2 T1	225	B	
I1 T1	216	C	
I1 T4	210	C	
I2 T4	180	D	
I1 T2	163	E	
I2 T2	149	F	

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Table (5) show significant differences in the effect of water depletion levels on leaf area. Treatment I1 (75% depletion) had a leaf area of 4408 cm^2, while treatment I2 (50% depletion) had a leaf area of approximately 4534 cm^2, indicating a 126 cm^2 increase in leaf area compared to I1. This resulted in water deficit, which could reduce leaf area and related photosynthetic activities, ultimately having a detrimental impact on leaf area. In contrast, there was a significant difference in the effect of soil texture types on leaf area. T3 (Sandy Loam) had the highest leaf area (5046 cm^2), followed by T1 (Loamy Sand) with 4584 cm^2, T4 (Silty Loam) with 4521 cm^2, and T2 (Sand) with 3732 cm^2. This suggests that sandy loam (T3) is optimal for increasing leaf area, while sandy soil (T2) has a negative effect. There were substantial differences in the interaction effect of depletion levels and soil texture. Treatment I2 T3 had the highest average leaf area of 5052 cm^2, while I1 T2 had the lowest at 3588 cm^2. This suggests that combining water availability (I2) with sandy loam soil (T3) leads to increased leaf area, while combining I1 and T2 results in the lowest leaf area. These findings suggest that water availability contributes to increased leaf area, which could be attributed to the influence of different plant growth stages on water availability, affecting all plant physiological processes, including leaf area, which are influenced by moisture content as well as the timing and quantity of water application. Cakmakci and Sahin [9] found that these physiological changes in plants are mirrored in the average leaf area. Larger leaf areas typically indicate better photosynthesis, leading to higher growth rates and productivity. Soil texture influences water retention and nutrient availability, while depletion levels affect the amount of water available to the plant. Research has shown that plants with larger leaf areas are more efficient at capturing light and CO_2, which are essential for photosynthesis. A study by [14] found that leaf area index (LAI) is a reliable predictor of crop yield and biomass production. They demonstrated that optimal water management and suitable soil textures lead to increased LAI. The development and performance of the entire plant are therefore improved [14.[

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Table (5) Impact of depletion levels (I1 = 75%, I2 = 50%) and soil texture types (sandy loam, loamy sand, silty loam) as well as their interaction on leaf area (cm2 .(

INDEPENDENT VARIABLE	DEPENDENT VARIABLE	GROUPING	LSD VALUE
DEPLETION LEVEL	**leaf area cm^2**		
I2	4536	A	60.40
I1	4408	B	
SOIL TEXTURE	**leaf area cm^2**	**Grouping**	**LSD Value**
T3	5046	A	85.40
T1	4585	B	
T4	4521	B	
T2	3738	C	
DEPLETION LEVEL AND SOIL TEXTURE INTERACTION	**leaf area cm^2**	**Groups**	**LSD Value**
I2 T3	5052	A	121
I1 T3	5040	A	
I2 T1	4633	B	
I2 T4	4575	BC	
I1 T1	4537	BC	
I1 T4	4466	C	
I2 T2	3885	D	
I1 T2	3590	E	

.5Ear length (cm(

Table (6) showed that irrigation depletion levels had a substantial effect on corn ear length, with 50% depletion (I2) resulting in an average corn ear length of 19 cm, while it was 17 cm at 75% depletion (I1). Appropriate water availability at important growth stages improved photosynthesis efficiency and nitrogen uptake. [10]. Table (6) demonstrated that a loam soil (T3) produced the highest with a corn ear length of 22 cm, while sandy soil (T2) had the least corn ear length (16 cm). The interaction between (I2T3) treatment had the highest corn ear length of 23 cm, while it was 20 cm in the (I1T3) interaction. Effective water management and soil quality were critical for increasing crop output and reducing drought risk

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Table (6) Impact of depletion levels (I1 = 75%, I2 = 50%) and soil texture types (sandy loam, loamy sand, silty loam) as well as their interaction on ear length (cm .(

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INDEPENDENT VARIABLE	DEPENDENT VARIABLE	GROUPING	LSD VALUE
DEPLETION LEVEL	**Corn ear length (cm)**		
I2	19	A	0.71
I1	18	B	
SOIL TEXTURE	**Corn ear length (cm)**	**Grouping**	**LSD Value**
T3	22	A	1.00
T1	19	B	
T4	17	C	
T2	16	C	
DEPLETION LEVEL AND SOIL TEXTURE INTERACTION	**Corn ear length (cm)**	**Groups**	**LSD Value**
I2 T3	23	A	1.42
I1 T3	20	B	
I2 T1	20	B	
I1 T1	18	C	
I2 T4	17	CD	
I2 T2	16	DE	
I1 T4	16	DE	
I1 T2	16	E	

.6Ear number per plant

Table (7) show no significant differences among treatments, indicating that water depletion levels didn't affect corn ears/plant. All corn ears remained at 2 corn ears/plant regardless of depletion ratio. This stability is due to capacity of maize to tolerate water depletion. Soil texture did not change ear numbers, likely due to adaptability of maize crop. Interactions between depletion level and soil texture showed variations, with sandy and silty soil decreasing to 1 corn ear/plant under 75% depletion. These outcomes were Consistent With Scott And Renaud [1
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Table (7) Impact of depletion levels (I1 = 75%, I2 = 50%) and soil texture types (sandy loam, loamy sand, silty loam) as well as their interaction on ear numbers per plant

INDEPENDENT VARIABLE	DEPENDENT VARIABLE	GROUPING	LSD VALUE
DEPLETION LEVEL	**Corn ear number**		
I2	2	A	0.29
I1	2	A	
SOIL TEXTURE	**Corn ear number**	**Grouping**	**LSD Value**
T3	2	A	0.40
T1	2	A	
T2	2	A	
T4	2	A	
DEPLETION LEVEL AND SOIL TEXTURE INTERACTION	**Corn ear number**	**Groups**	**LSD Value**
I1 T3	2	A	0.56
I2 T1	2	A	
I2 T2	2	A	
I2 T3	2	A	
I2 T4	2	A	
I1 T1	2	AB	
I1 T2	1	B	
I1 T4	1	B	

.7Dry root weight (g(

Table (8) shows that there are no significant differences in the impact of depletion levels on plant average dry root weights. Both depletion levels resulted in dry root weights of 45.25 g and 43.75 g. The results demonstrate that plants in (75% water depletion) treatment had the same root weight rate. Recent study supports this, indicating that water stress

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enhances plant root growth, resulting in increased overall root weight. Table (8) also demonstrates large variations in the impact of soil texture on average root weight. T2 soil (sandy) had the most substantial dry root weight at 50 g, while T1 soil (loamy sand) had 45 g. The results show that sandy soil enhances water drainage, requiring plants to grow deeper and thicker root systems in order to access residual water in the soil, hence increasing root weight [12]. In contrast, silty soil held more water, reducing the need for plants to develop deep root systems [13]. The findings reveal that both water depletion and soil texture have a significant effect on root growth and weight. They can contribute to better irrigation and agricultural management practices, resulting in higher crop productivity. Table (8) shows the influence of water depletion level and soil texture on root weight in each plant .

Table (8) Impact of depletion levels (I1 = 75%, I2 = 50%) and soil texture types (sandy loam, loamy sand, silty loam) as well as their interaction on root weight (g.(

INDEPENDENT VARIABLE	DEPENDENT VARIABLE	GROUPING	LSD VALUE
DEPLETION LEVEL	**Dry root weight (g)**		
I1	45.25	A	2.71
I2	43.75	A	
SOIL TEXTURE	**Dry root weight (g))**	**Grouping**	**LSD Value**
T2	50.00	A	3.83
T1	45.00	B	
T3	42.50	BC	
T4	40.50	C	
DEPLETION LEVEL AND SOIL TEXTURE INTERACTION	**Dry root weight (g)**	**Groups**	**LSD Value**
I1 T2	51.00	A	5.41
I2 T2	49.00	AB	
I1 T1	46.00	ABC	
I2 T1	44.00	BCD	
I1 T3	43.00	CD	
I2 T3	42.00	CD	
I1 T4	41.00	CD	
I2 T4	40.00	D	

Conclusion

The experiment looked at how soil texture and water depletion levels influenced some maize traits. Results demonstrated that 50% water depletion (I2) resulted in considerably bigger stem diameter, total dry matter or biological yield, stem height, and leaf area than 75% depletion (I1). The study discovered that soil texture T3 (Sandy loam) contributed the most favorable circumstances for stem development, total dry matter stem height, and leaf area. Overall, the experiment showed that optimal water resource management can encourage crop productivity, helping to ensure food protection and sustainability.

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