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Assessment of Water Use Efficiency in Fields: Impact of Water Depletion Levels and Soil Textures on *Zea Mays*

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Abstract

Global water shortage is a major problem that needs for efficient irrigation management to provide food security and sustainable agriculture. n experiment was carried out in the fall of 2023 in Al-Musayyib, Babylon Governorate, Iraq. The aim of this work was to investigate how soil texture and irrigation depletion levels (I1 = 75% and I2 = 50%) affected the performance of the maize crop. The soil textures at the experimental site are sandy, loamy, sandy loam, and clay loam. Sandy loam soils (T1) had the greatest total excess water depth (I1) at 75% water depletion (I1), followed by sandy soils (T2) at 1425 $mm.season^{-1}$. While sandy loam soils (T1) needed 1279 $mm.season^{-1}$ at 50% water depletion (I2), sandy soils (T2) needed 1463 $mm.season^{-1}$. These statistics show how a growing water scarcity calls for more irrigation. Besides, sandy and sandy loam soils need less water than clay or sandy clay soils. For the same soil type, I1 needed less watering than I2, and loamy sands showed the most drop in cob length. Rich moisture retention indicated by the least amount of watering needed for maize in sandy loam soils, while sandy soils required the highest. The length of maize cobs was affected by soil type and irrigation level. Silt loam soil developed longer cobs, while 75% depletion level had shorter corn cobs. Watering schemes have to take soil quality and water depletion into account in order to achieve optimal water utilization and production of crops. Improved irrigation management can increase crop yields while consuming less water.

Keywords:

Soil texture, depletion, maize, water efficiency.

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Introduction

We need to learn more about how to use water in farming because Iraq has a big water problem. Iraq is having a harder time getting water because of climate change, population growth, and more factories and farms being built (Al-Ansari, 2013). Iraq is one of many Arab countries that have trouble with water. Climate change also makes things worse by bringing more weather and less water (UNDP, 2020). This problem makes me think about both how important it is to drink enough water and keep food safe (FAO, 2017).

Before we can handle water well and for a long time, we need to learn a lot about how fields use it (UNDP, 2020). The study needs to know how much water different crops need in order to find ways to save water without lowering the amount of food that can be grown (FAO, 2017). Also, farms will use water better, and the way plants are watered will change. With these numbers, you can make long-term plans for food security and clean water (Ministry of Water Resources, 2019).

Iraq needs more feed foods, like maize (Zea mays), because there are more cattle there (FAO, 2017). It's also important to know how much water things like yellow maize need because more than 70% of Iraq's water is used for farming. People in Iraq and around the world are interested in how much water maize needs (Al-Ansari, 2013; Srkalović & Stjepić Srkalović, 2020).

It's thought to be important to learn how much water plants need since Iraq has trouble managing its water sources and doesn't have enough. It has been looked into how much water different crops in northern, central, and southern Iraq need (Shukr, 2023). No matter how hard people work, there is still not enough study in this area. Al-Obaidi et al., (2022) say this is especially true because most of the studies haven't looked at important things like how dry Iraq is and the different kinds of dirt that it has. A test will be done in this study to see how much water maize needs to make up the difference. You can find corn in Iraq and it's easy to grow. There will be enough food for everyone in the country because of the project. Farmers will be able to handle water better. The main point of this study was to keep track of how much water is used and spread. This was done to see how well places use water. The study also wants to look at how the land's shape and the amount of water used change over time (Nandy & Dubey, 2024).

Material and Methods

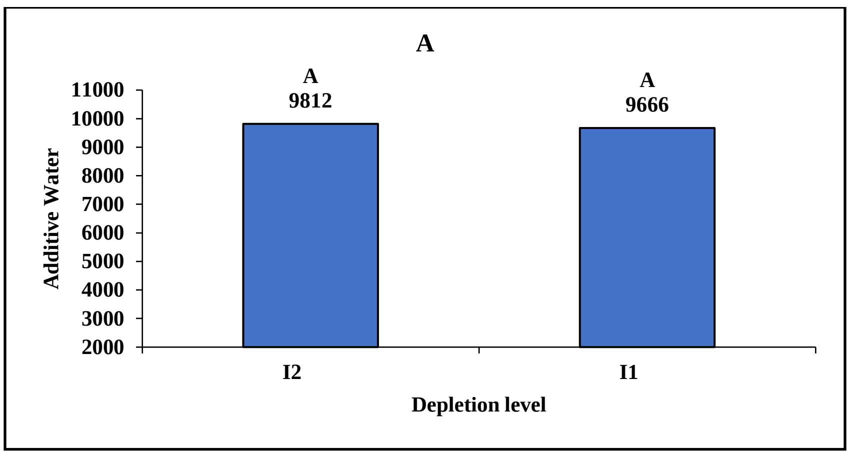
In the autumn of 2023, the test took place in a farming area in the Al-Musayyib district of Iraq's Babylon Governorate. At 32.58914529°N and 44.27791782°E, 30 meters above sea level, the field was found. The experiment was conducted on a 200-square-meter area within the field. Two trenches were dug, each measuring 1 meter deep, 7.5 meters long, and 0.5 meters wide. Sixteen pre-prepared plastic barrels were placed along the edges of one trench, eight on each side. An extra eight barrels were placed on one side of the second trench, resulting in three replicas totaling 24 lysimeters. Four different soil textures (sandy, loamy, sandy loam, and clay loam) were collected and deposited in 24 plastic barrels measuring 1 meter tall and 0.29 m in diameter. A drainage tap was constructed at the bottom of each barrel to manage the outflow of leached water, and a layer of fine gravel measuring 0.1 m was added to prevent soil erosion. Three hybrids of yellow corn seeds were sown in each barrel at a depth of 0.02 meters. Water bottles, graduated cylinders, water tanks, and tensiometers were used to assess soil moisture tension and create irrigation schedules. Before planting, random soil samples were obtained from each of the four soil textures at depths ranging from 0 to 0.7 meters (Admasu et al., 2019). The dirt samples were first left out in the open air to dry out so that scientists could study their physical and biological features. Then they were broken up and put through a 2 mm mesh sieve. A randomized complete block design (RCBD) with 24 different drugs was used in the test. Soil came in four types: sandy, loamy, sandy loam, and clay loam. There are two ways to water them: 75% (Niu et al., 2022) or 50% (Ouattara et al., 2017).

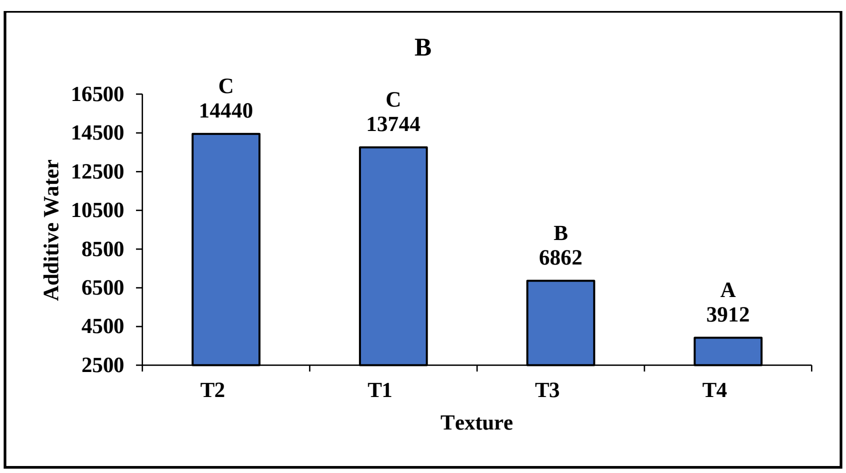
Each kind had three of them. It was Stats version 10 that I used to look at the data and do an ANOVA. To determine significant differences between the treatment means, the Least Significant Difference (LSD) test was performed at a 5% probability level ($P \leq 0.05$).

Results and Discussion

1. Total Applied Water (m^3.h)

Figure (1A) shows the effect of different irrigation depletion levels on the amount of applied water at a significance level of 0.05. The data show that depletion level I1 (75%) yielded 9812 m^3.h of applied water, while depletion level I2 (50%) yielded around 9666 m^3.h. There were no significant variations between the two depletion levels. Figure (1B) demonstrates significant changes in the impact of soil texture (loamy sand, sandy loam, silt loam) on the amount of applied water at the same significance level of 0.05, as shown in Table 1. Texture T2 used about 14440 m^3.h of water, while texture T1 used around 13744 m^3.h. Texture T3 applied 6862 m^3.h of water, while texture T4 had the most efficient impact at 3912 m^3.h due to its fine texture and high-water retention capacity. Figure (1C) depicts the interaction effect of irrigation levels and soil texture on applied water quantity. There were no significant differences between treatments I1T1, I2T2, T2I1, and I2T1, using water volumes of 14700, 14630, and 14250 m^3.h, respectively. However, the interaction impact between I1T3, I2T3, and I2T4 was significant at the same level. I1T4 was the most efficient in water retention (about 2797 m^3.h) (Jayapriya, 2021).





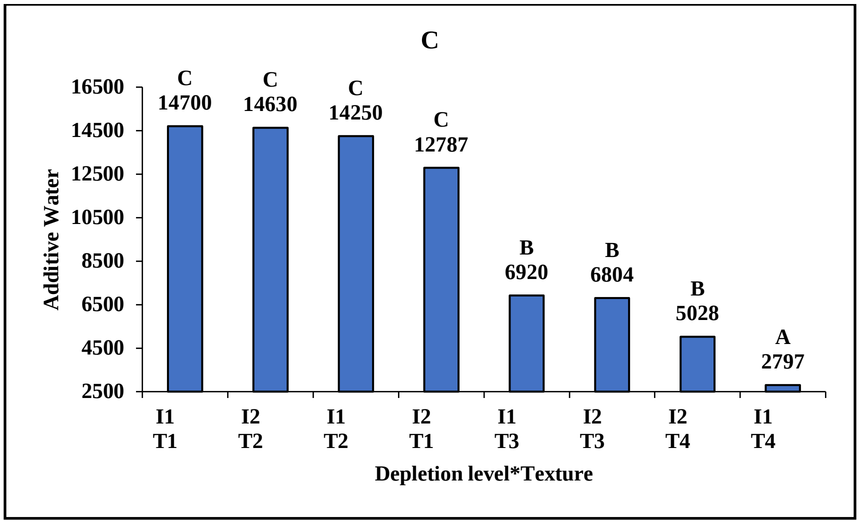


Figure (1A). Represents the impact of depletion levels (I2 = (50%), I1 = (75%) on the total applied water for yellow corn crops. (Figure 1B): Illustrates the effect of soil texture (loamy sand, sandy loam, silt loam) on the total applied water. Figure (1C): Depicts the interaction effect between soil texture and depletion levels on the total applied water

The data clearly show that the irrigation depletion level has no significant effect on the applied water quantity between I1 and I2. This shows that water use efficiency is similar at these two levels, and little alterations may not be enough to have a substantial impact. These findings were consistent with (Wang et al., 2021). Significant differences in soil texture suggest that soil type influences the amount of water applied. Soils with loamy sandy and loamy clay textures hold more water than sandy and clayey soils, demonstrating how soil physical and chemical qualities affect water retention and drainage. Kuschel-Otarola et al., (2020) said the same thing. Some treatments didn't make a big difference, so there must be a link between the type of grain and how much water was lost. However, irrigation can sometimes make a big difference, especially when used with I1T4, which is the best building for keeping water in. We found the same things that (Niu et al., 2022; Amami et al., 2021). More than one thing can change how much water maize plants get. These things are the shape of the land and how much water has been used to water it (Tandon, 1995; Robles et al., 2015).

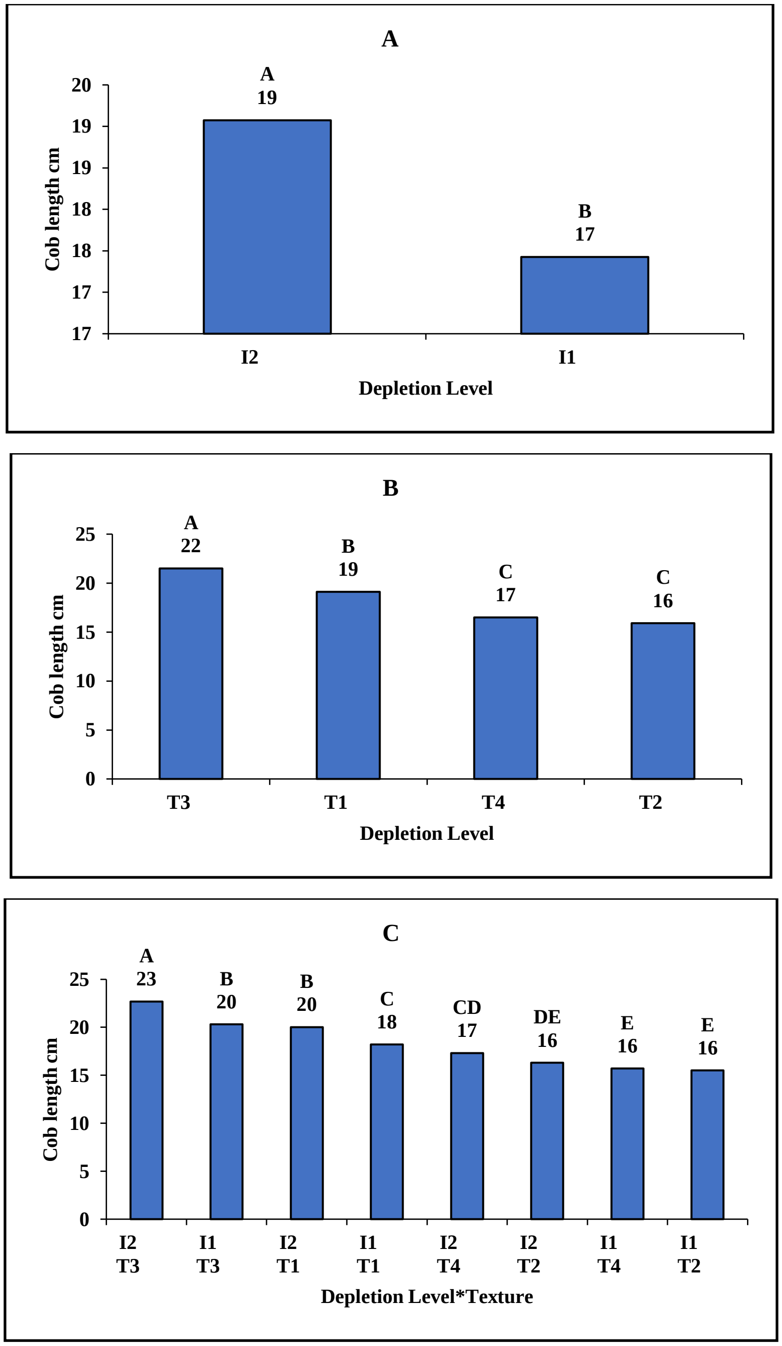
2. Cob Length CM

When different amounts of water are lost, Table 2A shows that the length of a cob changes by 0.05 centimetres. The 50% more loss seems to have changed the longer cob (17 cm) (Ouattara et al., 2017). The least amount of loss was 75%, which was about 19 cm below. That's since less water is being used. The corn cobs might get longer when there is more water. Rahimi-Moghaddam et al., (2019) did a study that showed how good control of water can greatly boost food production. That's what this study shows (Hussain & Taimooz, 2024).

We used a 0.05 level of significance to show that there were important changes in the cob length cm between the three types of soil in Figure 2B. There are three kinds of soil: silt loam, sandy loam, and loamy sand. The cobs were about 22 cm long and grew in dirt that was type T3 silt clay. T1 was the name of a 19-cm-long sand tube. The cobs were about 17 to 18 cm long, so there wasn't a big difference between the sandy loams (T4) and (T2). We found that the type of silt loam soil seems to have the most important effect on how long corn cobs are in centimetres. The number of plants that grow and how well the soil holds water are both affected by how rough it is, as found (Tremblay et al., 2012; Tanure et al., 2019).

When you water the ground, how rough it is affects how much water you lose (Figure 2C).

The cobs in I1T3 (75% depletion, silt loam) and I2T1 (50% depletion, silt loam) were both about 20 cm long. Not a lot of big things changed between them. When I2T3 was used, most of the cobs were about 23 cm long, which is 50% shorter. The cobs from I1T1 (75% depletion, silt loam) and I2T4 (50% depletion, sand soil) were each about 17 cm long. The I1T4 and I1T2 cobs were about 16 cm long. A study (Attia et al., 2021) says that if you want to grow more food, you should use both soil factors and washing ways at the same time.



(Figure 2A). This graph shows how the length of the cob changed when the depletion amount was I2 (50%), I1 (75%), or I3. (Check out Picture 2B) Because of the different types of soil (loamy sand, sandy loam, and silt loam), the length of the cob changes. (Check out Picture 2C) The length of the cob changes by inches depending on the type of ground and the amount of loss

It turns out that if you want to get more corn cob, you need to think about both how much water has been used up and how good the land is. It looks like the best way to get more corn cobs from each plant is to use silt clay soil and give plants less water. These results agree with those of (Ouattara et al., 2017), who also said that farming needs to be able to control land and water.

3. Total Added Water Depth mm.season-1

Figure 3 displays that sandy loam soils (T1) had 1470 mm/season more water than other types of soils when 75% of the water was gone (I1). The next type was sandy soils (T2), which got 1425 mm of rain every year. At that point, half of the water was gone (I2). The sandy soil treatment (T2) had 1463 mm.season-1 more water than the sandy loam soil treatment (T1), which had 1279 mm.season. At the 75% water drain (I1), all the soil solutions got more water than at the 50% water drain (I2). That is, the amount of water needed to water the crop goes up as water loss goes up.

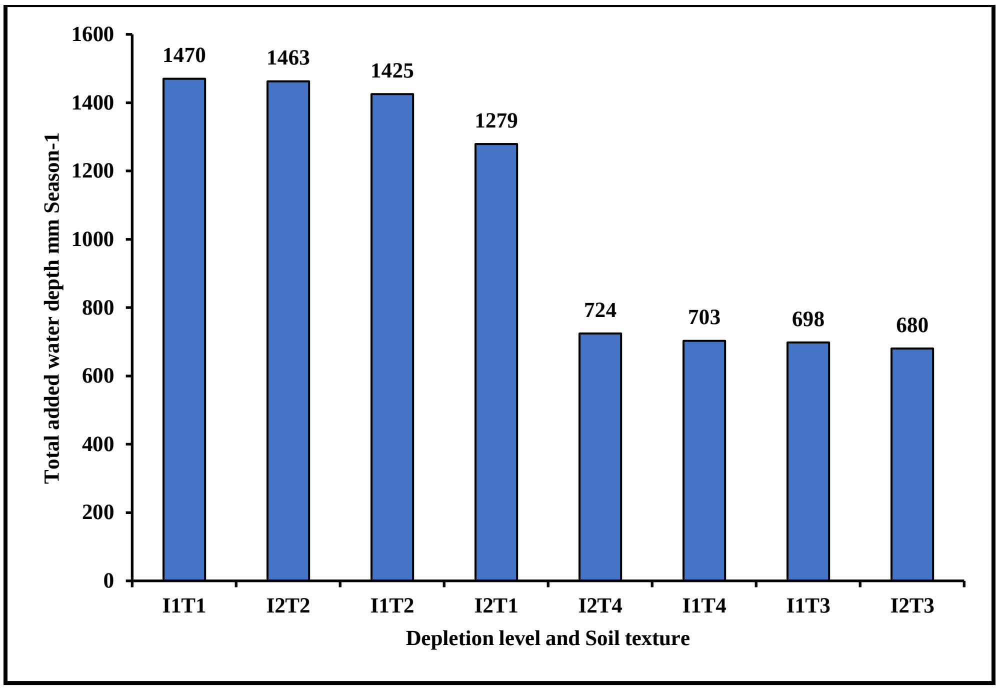


Figure 3. Effect of depletion level and soil texture on total added water depth mm.season^{-1}

To figure out how much water a plant needs, you need to know how good the dirt is. Ismail & Ozawa et al., (2007) (8) that sandy soils lose water faster than clay soils and need more water to make up the difference. It was 75% dry and sandy soils (T2) and sandy loam soils (T1) still needed the most water (I1). Next were clay soils (T4) and sandy-loamy soils (T3). Sandy earth (T2) needed the most water when it was half dry. Sandy loam soil was the next type (T1). Different types of dirt need different amounts of water. Clay and sandy clay soils need less water than sand and sandy loam (Huang & Hartemink, 2020). To plan how to water well, you should look at how the land is and how much water is lost. They will be able to figure out how much water their crops need better, which will save them money. Plants will grow faster and water will stay on the soil if you change how much you water them.

4. Number of Watering

During the growing season, corn needs to be watered based on how wet and rough the dirt is. It took less watering for the I1 (75% depletion) treatment than for the I2 (50% depletion) treatment on the same type of soil. T1 had 19 watering for loamy sand, T2 had 21, T3 had 12, and T4 had 10 for sand, sandy loam, and silt loam. The water level did the same thing when it was 75% low (I1). It was necessary to water the loamy sand (T1) 23 times, the sand (T2) 29 times, the sandy loam (T3) 17 times, and the silt loam (T4) 16 times. Illustrates the effect of soil texture and water depletion on the number of maize crops that are watered shown in Figure 4.

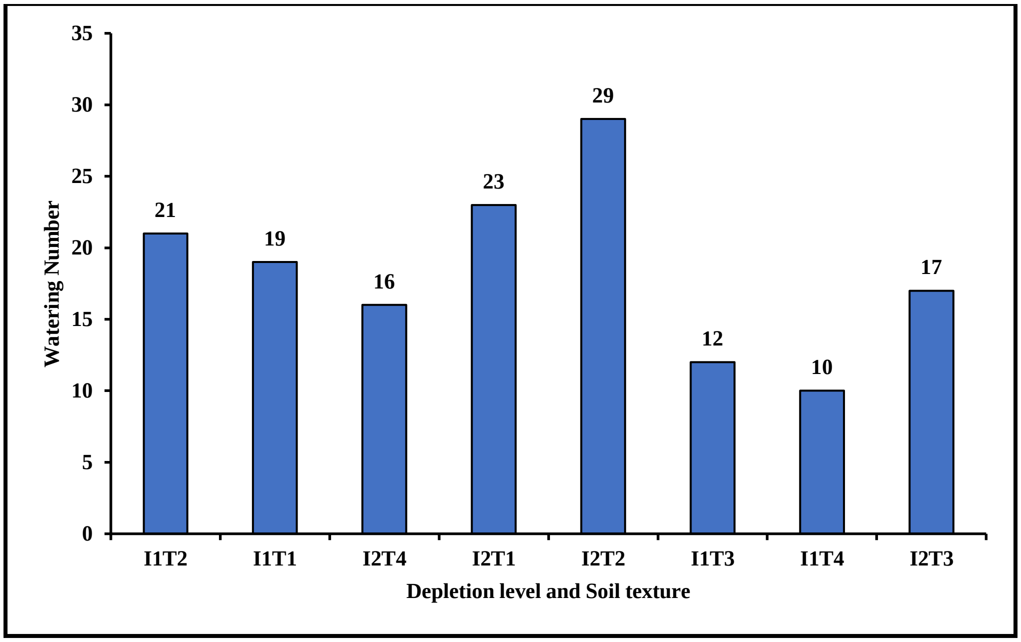


Figure 4. Illustrates the effect of soil texture and water depletion on the number of maize crops that are watered

All soil types needed fewer watering events at 75% depletion than at 50% depletion, according to the study. This might be explained scientifically as such. A greater depletion level means that the soil holds less water before irrigation, therefore fewer but bigger watering sessions are needed to make up for the shortfall. This result is consistent with earlier research, which concluded that the amount of water needed for irrigation is determined by the degree of soil water depletion; drier soil needs more. These results support the first observation that sandy soils need more water to make up for losses brought on by their deteriorated capacity to retain moisture. This study's results agreed with and those of (Meskelu et al., 2014) in 2014 indicated that water depletion increased, so did the amount of water needed for irrigation.

Watering schedule is greatly influenced by soil texture, because of its bigger particles and wider gaps, sandy soil needed the most watering (I2T2: 29) because it drained water quickly and had low ability of water retention. Watering was thus needed more frequent to make up for the quickly moisture loss. Compared to sandy soil, silt loam needed the fewest watering events (I1T4: 10) because of its much smaller particles, which prolonged the duration that water could be held and reduced the need for frequent irrigation. Smaller particles suggest smaller pores, which causes higher moisture retention and slower water drainage.

In contrast, sandy and sandy loam soils necessitate more frequent watering than silt loam and loamy sand soils. The proportion of large to small particles in sandy and sandy loam soils impacts their water retention and drainage capacity. Soils with a higher clay percentage retain more water, requiring less watering.

Conclusion

The experiment showed, in the end, how important soil texture and irrigation depletion levels are to corn yield. Greater water depletion required more irrigation, especially in sandy and sandy loam soils with poor moisture retention. When water depletion reached 75%, silt loam soil needed the least amount and sandy loam soil the most. Maize cob height per plant declined with increasing depletion levels; silt loam soils produced the highest cob corn height in centimeters.

Author Contributions

All Authors contributed equally.

Conflict of Interest

The authors declared that no conflict of interest.

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