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The effect of some soil conditioners and moisture deficiency on the weighted mean diameter and growth of maize (Zea mays L.) cultivated in desert soils.

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Abstract:

The experiment was conducted at the Tomato Development Research Station, located in Al-Zubayr district, Basra Governorate, with a sandy loam texture, during the autumn season of August 21, 2022. The objective of the study was to determine the effect of soil conditioners (zeolite at 2% and perlite at 1%, 2%, and 3%) with or without organic matter mixing, as well as the organic matter treatment at 3% and the control treatment, and the soil irrigation level on weighted mean diameter and growth of yellow corn (Zea Mays L.). The experiment was carried out in a randomized complete block design (RCBD) with three replications, and the means were compared using the least significant difference (LSD) test at a 5% probability level. The experiment included 10 treatments for conditioner and two irrigation levels (100% and 75%). The desired characteristics were studied at two depths: 0-15 cm and 15-30 cm at the beginning and end of the season. The results showed that the treatment ZO outperformed all other treatments in weighted mean diameter, recording 5.243 mm at the beginning of the season. However, at the end of the season, treatments ZO, B1O, B2O, B2, B3O, and B3 surpassed the other treatments. The irrigation level of 75% EP exhibited a significant increase of 11.45% in weighted mean diameter at the beginning of the season compared to the 100% EP irrigation level. However, at the end of the season, the 100% EP irrigation level showed a significant improvement in weighted mean diameter. Furthermore, at the beginning of the season, the 15-30 cm depth showed a significant increase in weighted mean diameter compared to the 0-15 cm depth, while there was no significant difference between the two depths at the end of the season. Treatment B3O showed a significant increase in plant height, recording 185.95 cm. Treatments B3O, B3, B2O, and ZO exhibited significant increases in plant dry weight compared to all other treatments, with values of 10,966.67, 10,866.67, 10,633.33, and 10,233.33 kg/ha, respectively.

Keywords: Weighted mean diameter, zeolite, perlite, irrigation levels, sandy soil.

I. INTRODUCTION

Mohamed (2001) defined zeolite as crystalline aluminosilicate minerals consisting of a structure of [SiO_4] and [AlO_4]- tetrahedra interconnected through shared oxygen atoms. It is one of the most common minerals found in sedimentary rocks. The substitution of (Si^{+}_{4}) with (Al^{+}_{3}) in the tetrahedral surfaces creates a negative charge in the mineral structure. Nakhli et al. (2017) mentioned that the use of zeolite in soil improves water use efficiency (WUE) and nutrient use efficiency (NUE) in agricultural soil, thereby reducing the likelihood of surface and groundwater contamination due to fertilizer addition. Mahmoud (2013) found that the addition of zeolite improved the properties of sandy soil, enhanced its productivity, increased total porosity, water retention capacity, and field capacity. Zeolite is considered environmentally friendly, readily available, and cost-effective, and it is widely used in agricultural activities for improving soil properties. Hussain and Radi (2019) concluded that the use of four levels of zeolite amendment (0, 1, 2, 3, 4%) in a blended greenish soil improved its physical properties, including mean weight diameter (MWD). Moritani et al. (2010) stated that adding 10% zeolite amendment to sodic soil containing three different clay minerals (kaolinitic, allophanic, smectic) improved the aggregate mean weight diameter due to a decrease in exchangeable sodium. Perlite is a volcanic rock with a snowy white color and a maximum water content of 1%. It contains approximately 70-75% SiO_2 and 12-18% Al_2O_3. It is thermally treated at temperatures ranging from 760-1100°C, which increases its original expansion by 4-20 times. At 50% relative humidity, it contains small cavities that increase its surface area. The bulk density of raw perlite ranges from 0.9 to 1.1 g/cm³ (Nelson, 2012). Perlite is one of the methods used to improve irrigation efficiency in dry and semi-arid regions (Moradiyan et al., 2018). It was also found that adding perlite and zeolite to a sandy blended soil at levels of 1 and 2 g/kg-1 soil significantly affected the mean weight diameter compared to the treatment without amendments. Organic matter refers to the residues resulting from the decomposition of plant and animal waste by microorganisms, which are added to the soil. Al-Naimi and Al-Lawzi (2016) mentioned that adding organic matter to the soil caused an increase in MWD, attributed to the decomposition of organic matter that forms humic-clay complexes, which bind soil aggregates. Al-Hadi and Yahya (2014) stated that adding soil amendments significantly increased the MWD values of soil at a 75% irrigation level compared to the 50% and 100% levels. Al-Janabi and Al-Shekhly (2012) indicated that increasing irrigation levels led to a decrease in MWD values, with a value of 0.8 mm in the full irrigation treatment compared to 0.9 and 1.0 mm in the 50% and 75% levels of the evaporation pan, respectively. Gholamhoseini et al. (2013) reported improvements in dry matter and seed production in a sandy loam plant field experiment. AL-Shammary et al. (2018) conducted a field study to investigate the effect of perlite at three levels (0, 5, 10%) on tomato plants, where the average plant height was (77.8, 88.9, 89.3) cm, respectively. Al-Shammary (2020) also found a significant effect of organic matter levels and water quantities on plant height.

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The study aims to:

1- Investigate the effect of different types and concentrations of amendments on the mean weight diameter of sandy soil.

2- Study the impact of irrigation levels, amendments, depth, and their interactions on the mean weight diameter and plant growth.

II. MATERIALS AND METHODS

Experimental Site:

The field experiment was conducted at the research station of the Tomato Crop Development Project, which implements modern techniques under the supervision of the Directorate of Agriculture in Basra, located in the southeastern part of Al-Zubair district, Basra province, for the autumn agricultural season on August 21, 2022. The field is located at latitude 27.2592° N and longitude 44.6142° E, with a sandy mixed soil texture. It falls within the desert regions and is classified as Entisols under the order of Psamment and the great group of Torripsamments under the group of Typic Torripsamments Al-Atab, (2008).The selected field area was 500 m2.

Random samples were taken from various locations in the field after removing the plant cover (surface layer) at two depths: 0-15 cm and 15-30 cm. The samples were thoroughly mixed for homogenization, then air-dried, ground, and sieved through a sieve with a 2 mm opening. Some chemical and physical analyses were conducted on the samples prior to planting. Table 1 presents some of the physical and chemical properties of the study soil. The pH and electrical conductivity (EC) were determined in a soil-water extract (1:1 ratio). The calcium carbonate (CaCO3) content, particle size distribution, bulk density, particle density, total porosity, mean diameter, hydraulic conductivity, field capacity, and organic matter (O.M) content were analyzed according to the methods described by Black et al. (1965). The cation exchange capacity (CEC) was determined using the Papanicolaou method (1976). The soil penetration resistance was estimated using the equation mentioned by Gill and Vanden Perg (1968). In the soil-water extract (1:1 ratio), the concentrations of Ca^{+}_{2}, Mg^{+}_{2}, Na^{+}, K^{+}, SO_4^{-}, CO_3, HCO_3^{-} were measured following the method described by Page et al. (1982). The chloride ion Cl^{-} concentration was determined according to Richards (1954).

Table (1) Some of the physical and chemical properties of the study soil.

No.	Item		0-15 cm deep	15-30 deep	Unit
1	pH 1: 1		7.69	7.89	-
2	EC 1: 1		2.53	4.42	$ds.m^{-1}$
3	CEC		8.20	8.64	$Cmol .Kg^{-1}$ soil
4	positive ions	Ca^{+2}	27.24	29.10	$mmol. L^{-1}$
5		Mg^{+2}	10.43	2.5	
6		Na^{+1}	22.20	25.0	
7		K^{+1}	1.58	2.5	
8	negative ions	Cl^{-1}	23.00	38.0	
9		HCO_3^{-}	19.00	13.8	
10		SO_4^{-2}	15.10	13.6	
11		CO_3^{-2}	Nill	Nill	
12	CaCo3		200.00	225.00	$gm Kg^{-1}$ soil
13	Organic Mater		0.44	0.57	
14	Soil properties	Sand	856.00	833.00	
15		Silt	79.00	84.00	
16		Clay	65.00	83.00	
17	Soil texture		sandy loam		
18	Bulk density		1.33	1.51	$mg.m^{-3}$
19	True density		2.67	2.71	
20	Porosity		43.61	43.46	%
21	Saturated water conductivity		10.75	11.32	$cm^3 ha^{-1}$
22	Weighted diameter mean		3.67	3.70	mm
23	Soil penetration resistance		83	128	$KN m^{-1}$
24	Irrigation water		pH	Ec	
			7.12	8.73	

Experimental Treatments:

The experiment included the following soil conditioner: zeolite at a concentration of 2%, a treatment of organic matter mixed with a concentration of 1.5% + zeolite at a concentration of 2%, perlite at concentrations of 1%, 2%, and 3%, a treatment of organic matter mixed with a concentration of 1.5% + perlite at a concentration of 1%, a treatment of organic matter mixed with a concentration of 1.5% + perlite at a concentration of 2%, a treatment of organic matter mixed with a concentration of 1.5% + perlite at a concentration of 3%, organic matter at a concentration of 3%, and a control treatment (without any additives). The condtioners were added based on the dry weight of the soil. Some physical and chemical analyses were performed on the amended soil, as shown in Table (2).

Irrigation Levels:

Two irrigation levels were applied: 75% of the evaporation pan (Ep) and 100% of the evaporation pan (Ep). The amount of water to be added to the experimental units throughout the study period was determined based on the American class-A evaporation pan. The pan was installed in the middle of the field, raised 30 cm above the soil surface, and covered with a mesh to ensure evaporation only. To facilitate the calculation of the irrigation water quantity in cubic meters for each plot, the following equation was adopted:

$$The\ irrigation\ water\ \ amount\ (m3) per\ meadow = \frac{\text{evaporation from basin (mm)}}{100} \times meadow\ area\ (m2)$$

Field Agricultural Experiment:

Plowing, smoothing, leveling, and ridging operations were carried out in the field for the purpose of conducting the experiment. The soil was divided into three sections, with each section containing 20 experimental units with dimensions of 1.5 m x 1 m. A distance of 1 m was left between each experimental unit, starting from the end of one plot in the first experimental unit to the beginning of the next plot in the second experimental unit within the same section. A distance of 3 m was left between each section.

Table (2) Some conditioner properties were used in the study.

conditioner properties		Unit	Zeolite	Perlite
pH			8.12 (1:1)	7.5 (1:5)
EC		$ds.m^{-1}$	0.45 (1:1)	1.31 (1:5)
Bulk density		$mg.m^{-3}$	1.04	0.11
Colour			Black	White
Positive and Negative ions	Ca^{+2}	mmol. L-1	5.05	15.15
	Mg^{+2}		3.625	4,20
	Na^{+1}		4.00	28.26
	K^{+1}		0.18	1.36
	HCO_3^-		0.11	0.05
	CO_3^{-2}		0	0
	ClO_3		17.89	41.21
	SO_4^{-2}		3.86	7.85

The conditioners (zeolite, perlite, and organic matter) were added, and the irrigation level was set at 100% and 75%. Yellow maize seeds of the Dutch variety Vital were planted for the autumn season on August 21, 2022. The seeds were planted in rectangular-shaped plots with lines inside, with 2 lines in each experimental unit separated by a distance of 40 cm. Three seeds were placed at each spot and thinned to one plant. Fertilizers were added according to the recommended fertilization rates. Nitrogen was added in the form of urea fertilizer at a rate of 80 kg N per hectare, applied in two doses: one at planting and the other one month after planting. Phosphorus was added in the form of triple superphosphate fertilizer at a rate of 130 kg P2O5 per hectare, applied three days before planting. The plants were irrigated using a mixture of irrigation water (17.89 deciSiemens per meter) or well water (19.30 deciSiemens per meter) with R.O. water to reduce the salinity of the water to approximately 8.00 deciSiemens per meter. The herbicide diazinon was used to control ant insects, and the pesticide Future was used to control harmful insects for yellow maize at a rate of 150-200 cm per 100 liters of water one month after planting when the plants reached a height of 20-18 cm. Crop management activities were carried out throughout the growth period, and the harvest took place on December 10, 2022.

The studied characteristics were:

a. Mean weighted diameter (MWD) at the beginning and end of the season.

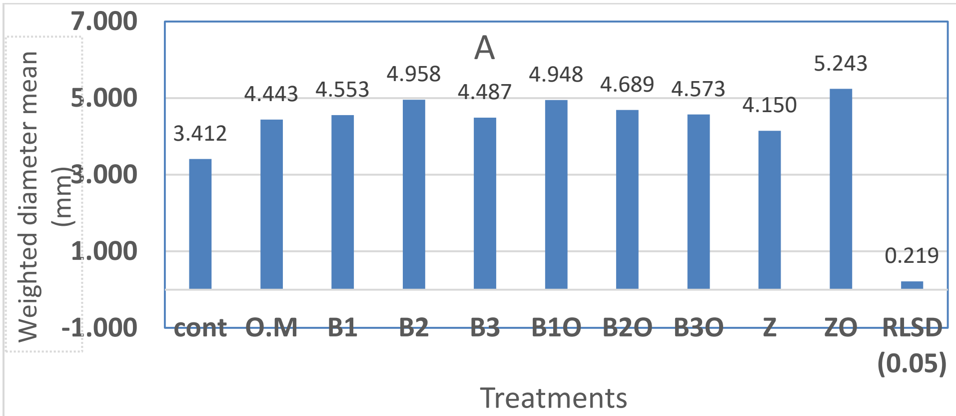
b. Plant growth parameters (plant height and dry weight) at the end of the growth season.

Statistical analysis:

The experiment was conducted using a randomized complete block design (RCBD), and the agricultural data were analyzed using the statistical software SPSS version 25. The significant effects of the factors and their interactions were determined using the F-test, and the least significant difference (LSD) test was used to compare means at a significance level of 0.05. The t-test was used to compare the beginning and end of the season.

III. RESULTS AND DISCUSSION

The effects of conditioners, irrigation level, depth, and their interactions on the mean weighted diameter (MWD) showed significant differences. According to the results presented in Figure 1 and the analysis of variance table (Table 2), there were significant differences among the conditioners in the values of MWD at the beginning of the season. The treatment with zeolite mixed with organic matter showed the highest significant value of 5.243 mm, followed by the treatments with 2% perlite and 1% perlite mixed with organic matter, which recorded values of 4.958 mm and 4.948 mm, respectively. There was also a significant difference between the treatment with zeolite mixed with organic matter and the treatment with only zeolite, with an increase of 26.34%. All treatments outperformed the control treatment, which had a value of 3.412 mm.



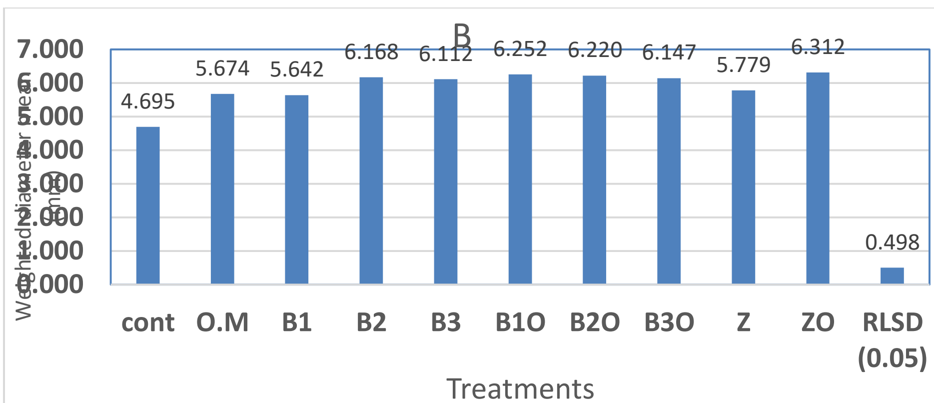


Figure (1) Effect of conditioner treatments on weighted mean diameter (mm) of soil (A) beginning of the growing season (B) end of the growing season.

Table (2) for the (F) test of the weighted diameter values at the beginning and end of the season.

sourse	df	MWD1	MWD2
A	9	22.512 **	7.059**
B	1	7.271 **	3.501 *
C	1	64.897 **	28.309**
A*B	9	.152 ns0	.971ns0
A*C	9	5.083 *	1.275ns
B*C	1	2.829 **	2.757**
A*B*C	9	.297ns0	.965ns0

MWD1: weighted diameter values at the beginning of season.

MWD2: weighted diameter values at the end of the season.

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Organic matter enhances the stability of soil aggregates by entering between soil particles and acting as an adhesive to bind the particles together. It also helps resist the detrimental effects of water movement during drainage (Annabi et al., 2014). Zeolite condtioner plays a role in aggregate formation due to its strong cationic exchange capacity, which allows it to replace K+, Mg+2, and Ca+2 ions with soil solution ions in an inverse manner. The presence of these ions enhances soil aggregation (Huo et al., 1991). Additionally, Bucci et al. (2005) found that the high calcium concentration in zeolite composition enables it to possess cationic exchange capacity, acting as bridges between organic and mineral colloids, resulting in stable aggregates with good physical and chemical properties.

The results in Figure 1 and the analysis of variance table (Table 2) indicate significant differences among the conditioners in the mean weighted diameter (MWD) values at the end of the season. All treatments showed significant improvement in MWD (mm) compared to the control treatment. The treatments (ZO, B1O, B2O, B2, B3O, B3) did not differ significantly from each other, with values of 6.312, 6.252, 6.220, 6.168, 6.147, and 6.112 mm, respectively. These treatments were followed by treatments (Z, O.M, B1) with no significant difference between them, recording values of 5.779, 5.674, and 5.642 mm, respectively.

For the same reasons mentioned earlier regarding the role of amendments in increasing MWD, as well as the role of organic matter in enhancing soil aggregate stability, and the role of zeolite in aggregate formation due to its strong cationic exchange capacity.

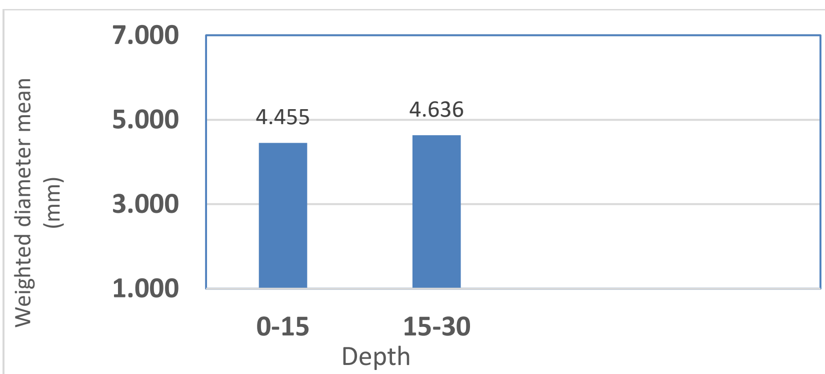
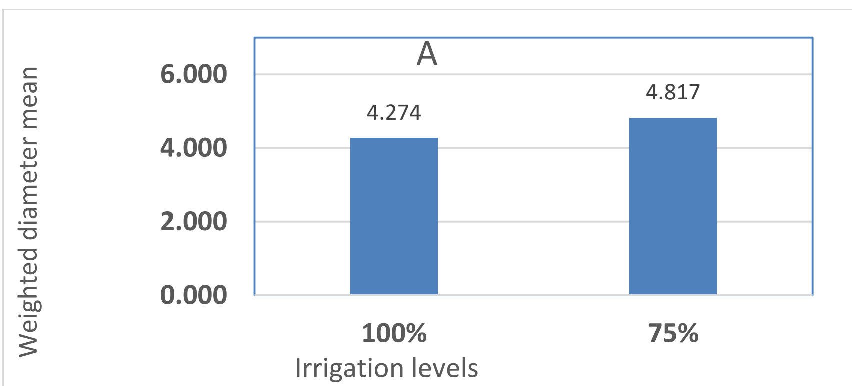


Figure (2) The effect of soil depth on weighted mean diameter (mm) of the soil at the beginning of the season

The results in Figure 2 and the analysis of variance table (Table 2) indicate a significant difference between the depths of 0-15 cm and 15-30 cm in the initial season MWD values. The depth of 15-30 cm showed a significant increase compared to the depth of 0-15 cm, with an increase of 4.06%. These results are consistent with the findings of Al-Madhi (2018). Randy et al. (2008) stated that the effect of wetting and drying cycles on soil aggregates lies in the sudden and rapid entry of water into the soil aggregates, resulting in uneven swelling in all parts of the masses or aggregates, leading to cracking and disintegration of those aggregates. Additionally, water entering the fine capillary tubes leads to the compression of trapped air inside the aggregates, causing air explosions within those aggregates that exceed the cohesive forces between the particles. Furthermore, the results in the analysis of variance table (Table 2) indicate no significant difference between the depths of 0-15 cm and 15-30 cm in the end-of-season MWD values.

The results in Figure 3 and the analysis of variance table (Table 2) indicate a significant difference between the irrigation levels (100% EP and 75% EP) in the initial season mean weighted diameter (MWD) values. The 75% EP irrigation level showed a statistically significant increase in MWD (mm) compared to the 100% EP irrigation level, with an increase of 11.45%.

Similarly, the results in Figure 3 and the analysis of variance table (Table 2) indicate a significant difference between the irrigation levels in the end-of-season MWD values. The 100% EP irrigation level showed a statistically significant increase in MWD (mm) compared to the 75% EP irrigation level, with values of 6.202 and 5.605 mm, respectively. The increase in MWD values during crop growth stages in the field is attributed to the convergence that occurs in soil aggregates when the soil reaches a state of stability after multiple irrigations and the increased binding forces between soil particles due to the effects of root exudates and root hair binding forces (Al-Murad, 1998).



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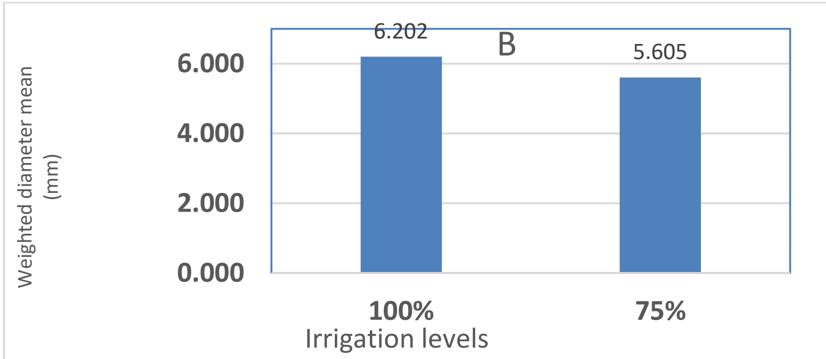

Figure (3) Effect of irrigation level on the weighted mean diameter (mm) of soil (A) beginning of the growing season (B) end of the growing season.

The results in Figure 4 and the analysis of variance table (Table 2) indicate a significant interaction between the additive treatments and soil depth in the initial season MWD values. The treatment with the addition of zeolite mixed with organic matter and the B2 treatment showed a statistically significant increase at the depth of 15-30 cm compared to all other treatments at the same depth, with values of 5.575 and 5.542 mm, respectively. However, the treatments mixed with organic matter had higher values than the treatments with only perlite and zeolite additives. Additionally, all treatments showed a statistically significant increase at both depths (0-15 cm and 15-30 cm) compared to the comparison treatment, which had the lowest MWD values, reaching 3.090 and 3.734 mm, respectively. Furthermore, the results and the analysis of variance table (Table 2) indicate no significant interaction between the additive treatments and the depths of 0-15 cm and 15-30 cm in the end-of-season MWD values.

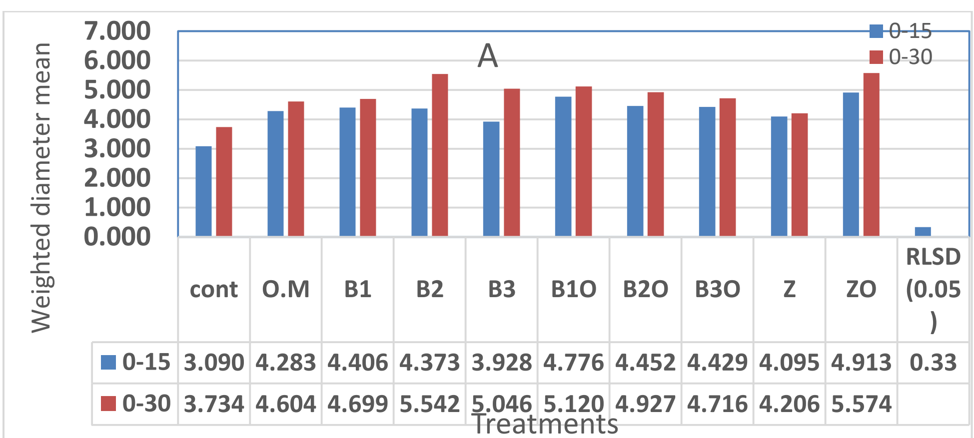

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Figure 4: The effect of the interaction between the additive treatments and soil depth on the mean weighted diameter (MWD) of soil at the beginning of the season.

The results in Figure 5 and the analysis of variance table (Table 2) indicate a significant difference in the interaction between the irrigation level and soil depth in the values of the mean weighted diameter at the beginning of the season. The 75% irrigation level showed a statistically significant increase in the mean weighted diameter (mm) compared to the 100% irrigation level at both soil depths of 0-15 cm and 15-30 cm, with an increase of 35.75% and 12.15%, respectively. The depth of 15-30 cm also showed a statistically significant increase in the mean weighted diameter compared to the depth of 0-15 cm for both the 100% and 75% irrigation levels. This can be attributed to the fact that the experimental soil is sandy and loose, and its structural stability is limited and affected by the irrigation process, especially at the surface depth. When irrigation levels increase, the soil structure is more easily disrupted at the surface depth (0-15 cm) compared to the subsurface depth (15-30 cm). This is because irrigation at the surface is faster, while the water flow rate in the subsurface depth (15-30 cm) is lower compared to the surface depth (0-15 cm), which is consistent with previous research (2018). Additionally, the results in the analysis of variance table (Table 2) indicate no significant difference in the interaction between the irrigation level and soil depth in the values of the mean weighted diameter at the end of the season.

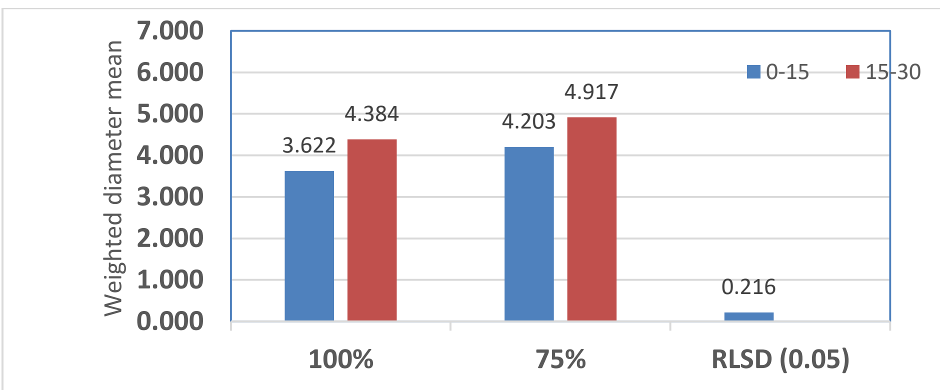

Figure 5 shows the effect of the interaction between the irrigation level and soil depth on the mean weighted diameter (in millimeters) of the soil at the beginning of the season.

The results in the analysis of variance table (Table 2) indicate no significant difference in the interaction between the additive treatments and irrigation level in the values of the mean weighted diameter at the beginning of the season. However, significant differences were found in the results in Figure 6 and the analysis of variance table (Table 2) for the additive treatments and irrigation level in the values of the mean weighted diameter at the end of

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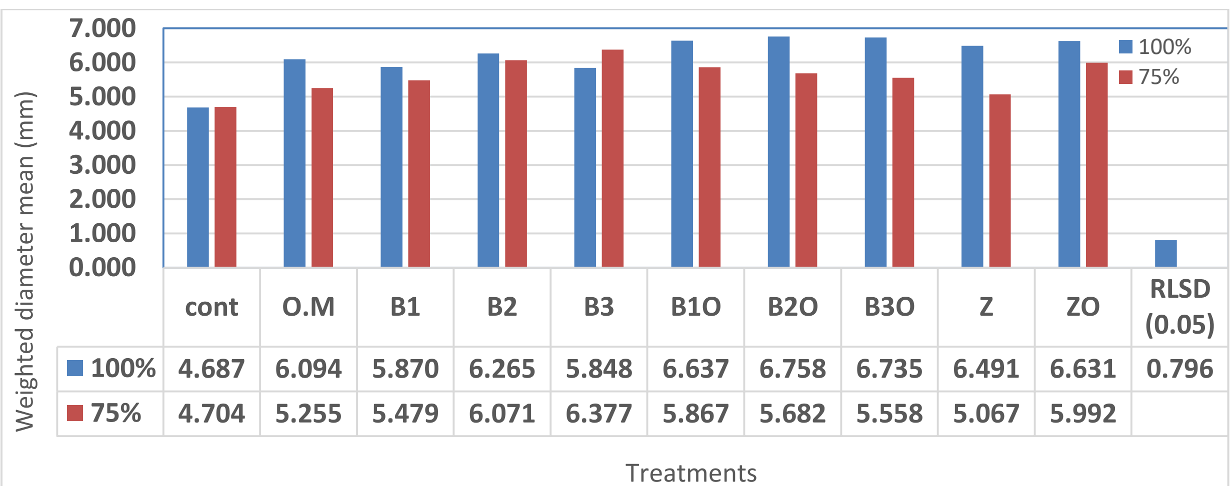
the season. The treatment with the addition of perlite at a 3% rate without mixing it with organic matter showed a significant increase in the mean weighted diameter compared to the other treatments (B2, ZO, B1O, and B2O) at the 75% irrigation level, with values of 6.071, 5.992, 5.867, and 5.682 mm, respectively. At the 100% irrigation level, all treatments with additives showed a significant increase in the mean weighted diameter compared to the comparison treatment, except for B1 and B3. This can be attributed to the fact that the surface layer is more susceptible to the effects of irrigation compared to the second layer. Therefore, the addition of additives reduced the variation in aggregate stability against the effects of irrigation by increasing the irrigation level. This is consistent with the findings of Al-Shami (2013). Additionally, Al-Atabi (2001) found a decrease in the values of mean weighted diameter after irrigation, attributing it to the breakdown of larger soil aggregates into smaller ones during the irrigation process, which reduces their stability. Therefore, increasing the amount of water leads to increased breakdown of aggregates and a decrease in the mean weighted diameter of the soil.

The analysis of variance table (Table 2) indicates no significant difference between the three possible interactions in the experiment at the beginning and end of the growing season. Furthermore, the t-test indicates a significant increase in the mean weighted diameter at the end of the season compared to the beginning, with a value of 1.262.



	cont	O.M	B1	B2	B3	B1O	B2O	B3O	Z	ZO	RLSD (0.05)
100%	4.687	6.094	5.870	6.265	5.848	6.637	6.758	6.735	6.491	6.631	0.796
75%	4.704	5.255	5.479	6.071	6.377	5.867	5.682	5.558	5.067	5.992	

Figure 6 shows the effect of the interaction between the additive treatments and irrigation level on the mean weighted diameter (mm) of the soil at the end of the growing season.

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The effect of adding additives and irrigation level on some growth parameters:

Plant height

The results in Figure 7 and the analysis of variance table (Table 3) indicate a significant difference between the treatments in plant height. The treatment with the addition of 3% perlite mixed with organic matter showed a significant increase in plant height, with a value of 185.95 cm, surpassing all other additive treatments. This was followed by the treatment with 3% perlite without mixing, which also showed a significant increase in plant height compared to the other additive treatments, with a value of 168.00 cm. Additionally, the treatments (B2O, ZO, and B2) showed a significant increase in plant height compared to the other treatments, with no significant difference between them. Furthermore, all treatments that had perlite added, either mixed with organic matter or without mixing, as well as the treatment with only organic matter, showed a significant increase in plant height compared to the treatment with 1% perlite alone, which recorded a value of 118.03 cm. Moreover, all additive treatments showed a significant increase in plant height compared to the comparison treatment, which recorded 106.76 cm. The significant differences and variations in the increase in plant height are attributed to the improvement in soil structure, which differs depending on the type of treatment and its associated increase in aggregate stability and reduction in bulk density. This positively affects the soil's water-holding capacity, which is a determining factor in dry areas, encouraging root development and enhancing plant vitality. This is consistent with Al madhi (2018).

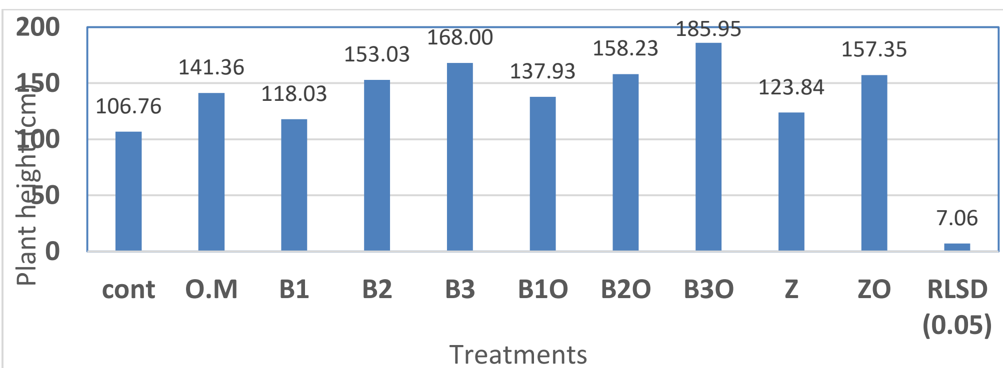

Figure 7 shows the effect of additive treatments on plant height (cm).

Table 3 presents the statistical analysis of the F-test for plant height and plant dry weight.

sources	df	Dry weight	Plant height
A	9	*9.138	*18.14
B	1	*2.124	*3.038

A*B	9	0.648 ^{ns}	0.377^{ns}

The reason for the superiority of the additive treatments, specifically perlite, in increasing plant height is attributed to the improvement of several soil properties such as mean weighted diameter (mm), as shown in Figure 1. This improvement creates favorable conditions for plant growth, including better air-water balance, which positively affects plant height. This finding is consistent with Mansour (2022). Additionally, the addition of zeolite as an additive helps reduce plant water stress. This contributes to improved plant height by mitigating the negative effects of water stress on cell division and reducing cell expansion effort, which is crucial for plant cell enlargement. Moreover, the addition of organic matter enhances the physical properties of the soil and increases the availability and accessibility of nutrients for root uptake. This positive role is reflected in plant growth, increased cell elongation rates, and consequently, increased plant height compared to the control treatment, as observed by Al-Mousawi (2021).

The results in Figure 8 and the analysis of variance table (Table 3) indicate a significant difference in plant height based on the irrigation level. The 100% irrigation level significantly outperforms the 75% irrigation level in terms of plant height, with recorded values of 157.05 cm and 133.05 cm, respectively. This can be attributed to the fact that increasing the irrigation level to 100% provides a higher moisture content for plant growth. It reduces the effort exerted by the plant to absorb water and increases the rates of photosynthesis and growth processes. This finding is consistent with Al-Busaidi et al. (2011). Additionally, Al-Awani (2005) indicated that insufficient soil moisture content at levels close to the permanent wilting point subjects the plant to higher effort in obtaining available water in the soil. The plant may not be able to meet its full water requirements for its vital processes, which affects the absorption and movement of nutrients from the soil to the plant. This, in turn, affects overall morphological characteristics, including plant height and dry weight of both above-ground and root biomass.

Figure 8 shows the effect of irrigation level on plant height (in centimeters). The analysis of variance table (Table 3) indicates no significant interaction between additive treatments and irrigation level in terms of plant height values.

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https://jam.utq.edu.iq/index.php/main *https://doi.org/10.54174/utjagr.v12i1.291*

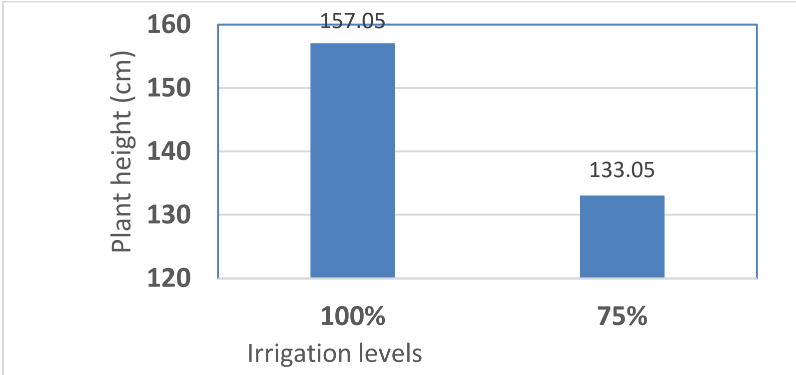

Figure (8) Effect of irrigation level on plant height (cm).

Dry Weight:

The results in Figure 9 and the analysis of variance table (Table 3) indicate a significant difference in the dry weight of plants among the additive treatments. The treatments B3O, B3, B2O, and ZO significantly outperformed all other treatments in terms of dry weight, with values of 10966.67 kg/ha, 10866.67 kg/ha, 10633.33 kg/ha, and 10233.33 kg/ha, respectively. The treatments O.M and B2 also outperformed the remaining treatments, with values of 8300.00 kg/ha and 8133.33 kg/ha, respectively. There was no significant difference between the treatments B1O, Z, B1, and the control treatment, which recorded a value of 5966.67 kg/ha. The addition of perlite, either mixed with organic matter or without mixing, resulted in an increase in the dry weight of plants. This finding is consistent with Hamdi (2017). The reason for this could be attributed to the role of added organic residues in improving the physical, chemical, and fertility properties of the soil, leading to increased availability of nutrients for plants. This, in turn, promotes root growth and proliferation, positively impacting other plant characteristics such as plant height and leaf area, ultimately increasing the dry weight of the plants. This finding is in agreement with Al-Mousawi (2021).

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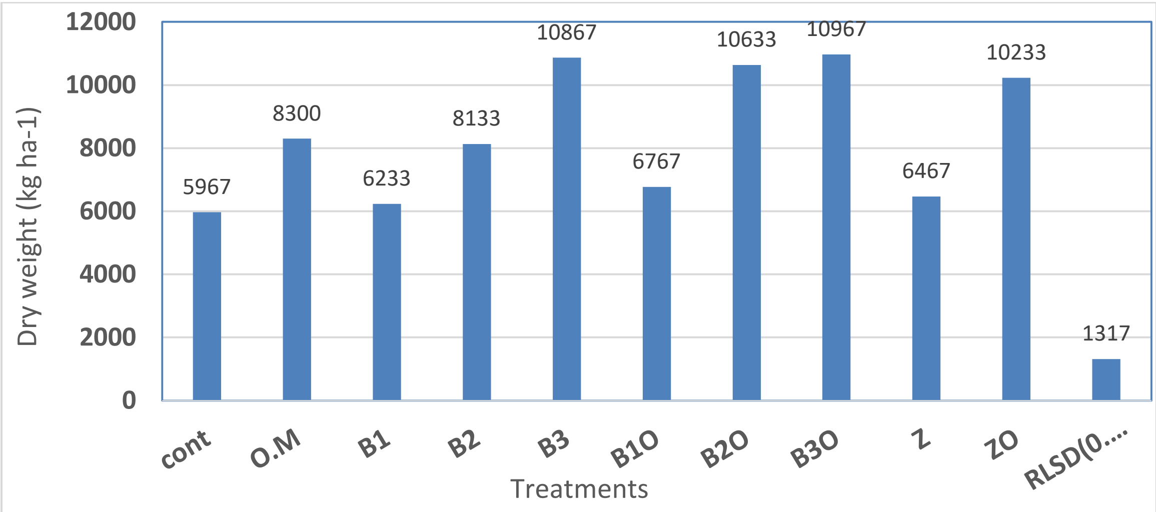

Figure 9 shows the effect of additive treatments on dry weight (kg/ha).

The results in Figure 10 and the analysis of variance table (Table 3) indicate a significant difference in the dry weight based on the irrigation level. The 100% irrigation level significantly outperforms the 75% irrigation level in terms of average dry weight, with a percentage increase of 13.74%. This can be attributed to the fact that increasing the irrigation level from 75% to 100% increases the moisture content in the soil and provides more available water for the plants. This, in turn, promotes root proliferation within the wet zone, reduces the plant's effort in water and nutrient uptake by alleviating stress on the roots, and increases turgor pressure. Sankar et al. (2007) explained that the decrease in the dry weight of the aerial part of the plant under water stress conditions could be due to a significant reduction in plant growth resulting from decreased photosynthetic efficiency. This, in turn, positively affects the increase in dry weight of the aerial part of the plant. This finding is consistent with Al-Busaidi et al. (2011).

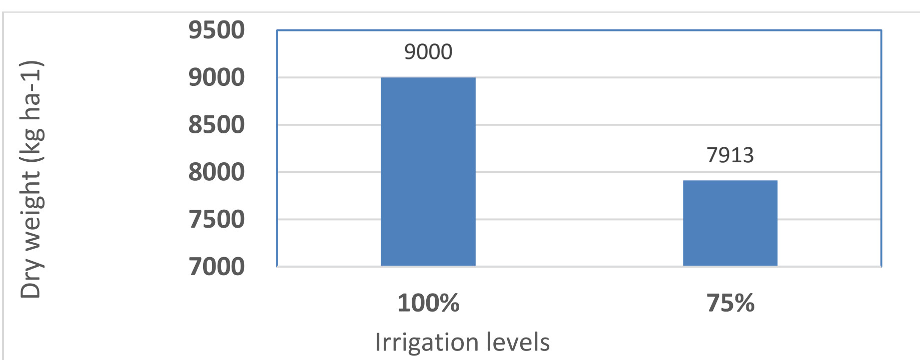

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Figure 10 shows the effect of irrigation level on dry weight (kg/ha).

The analysis of variance table (Table 3) indicates no significant interaction between additive treatments and irrigation level in terms of dry weight values.

IV. CONCLUSIONS

Treatment ZO outperforms other treatments in terms of average measured diameter in both seasons. Similarly, treatments B1O, B2O, B2, B3O, and B3 also show superior performance. Based on the results, it can be concluded that perlite can be used with a lower level of organic matter (O.M) in B1 treatment, as well as in the second and third levels, to reduce the addition of O.M to these soils. The 75% irrigation level outperforms the 100% irrigation level in terms of average measured diameter. Treatment B3O significantly outperforms other treatments in terms of plant height. In terms of dry weight, which is an important characteristic for plants, treatments B3O, B3, B2O, and ZO show superior performance. This finding aligns with the first conclusion that the addition of perlite alone can compensate for the addition or reduction of O.M. It is recommended to add zeolite and perlite while reducing the addition of organic matter (O.M) to improve various soil properties and enhance the growth of other plant components.

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