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Article

The Influence Of Operating Pressure In Solid Sprinkler Irrigation System, Moisture Depletion And Soil Pulverization At Mean Weight Diameter Of Clay Soil

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Abstract: During the agricultural year 2020–2021, an experiment was carried out in clay soil at the College of Agriculture / University of Basrah to investigate the impact of the elements under investigation on the mean weight diameter (MWD) in clay soil. The factors under investigation were as follows: the solid sprinkler irrigation system's operating pressure, which was set at 150 kPa (P1), 250 kPa (P2), and 350 kPa (P3); the moisture depletion, which was set at 75 % (M1) and 50 % (M2) of the available water; and the soil pulverization, which was set at two different levels: high pulverization (C), which was done once after plowing, and low pulverization (S), which was done three times after plowing. The findings indicated that the mean weighted diameter increased as the P1 to P2 and P3 outcomes increased. increase mean weighted diameter in treatment M1 comparison with treatment M2, high pulverization on (C) appeared high MWD comparison with (S) treatment in the middle and late growing season, barley crops are harvested respectively.

Keywords: Solid Sprinkler Irrigation, Moisture Depletion, Grade Of Soil Pulverization, Mean Weight Diameter.

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1. Introduction

Irrigation systems have developed from conventional surface irrigation systems to modern and advanced irrigation systems such as the sprinkler irrigation system, the target is to decrease water use, increase irrigation efficiency, increase crop productivity, and decrease water losses in the form of surface runoff, deep seepage, evaporation, and nutrient leaching ,the advantages of the irrigation system are summarized, spraying into economic, environmental, agricultural and irrigation management(O'shaughnessy et al.,2019). Using it through sprinkler irrigation, the water efficiency is about 70%, while in surface irrigation it reaches 50-60% and the water loss is more than 40% (Al-Kubaisi, 2001). Sprinkler irrigation has become a preferred method for growing grain crops since water became ready for irrigation around the worldwide, increasingly rare, particularly in arid and semi-arid areas, compared to sprinkler and surface irrigation, systems are they are used in more suitable operating conditions because they enable farmers to better control drainage rates, irrigation duration and efficiency (Abd El-Wahed et al.,2016).

Advanced sprinkler technology available water, fertilization, and exact control of irrigation time and the amount of water added to the plant, sprinkler irrigation is also used to irrigate many types of soils and crops in various topography with decrease labour cost and the ability to irrigate large fields (Attafy et al.,2017). Sprinkler irrigation system protects soil from wind and water erosion, as well as not lossing part of the field land to form field irrigation channels, and not needing drainage networks decrease to the lack of deep seepage losses and preserving the soil from compression during irrigation (Sui and Yan,2017). The primary motivation behind implementing new irrigation methods is the need to increase agricultural output, Soil properties deteriorate and soil structure is destroyed due to failure to choose an appropriate irrigation system, such as high bulk density, low total soil porosity, soil crusting, and high soil resistance to penetration (Jassim et al., 2009). influence energy a water droplets at operating pressure and type of sprinkler affects the soil surface large drops affect the soil surface erosion and a reason the porosity of the surface layer to close, leading to a decrease in the infiltration rate (Dwomoh et al.,2014).

Many agricultural operations affect the initialization of a suitable bed for the seed and the good emergence of plants, including pulverization, which improve the physical characteristics of the soil, such as the stability of soil aggregates, surface hardening, bulk density and the soil through its effect on the conditions of ventilation and humidity appropriate for plant growth and improving the quality of tillage through giving a good tillage and roughness appearance, The main purpose of using plowing equipment after the plowing process is to break up and pulverization the soil blocks, compact the seedbed well, and bury the crop and bush residues, which helps to create the appropriate conditions for germination and emergence, so pay attention must a given for this operation of pulverization by selecting the device machine, speed forward, and a number of times of pulverization appropriate to carry out this important process, as the repeated use of primary and secondary tillage equipment, such as repeated pulverization and perpendicular plowing, and the frequent passage of machinery and plowing equipment, perfrom to compaction of the soil and the deterioration structure and stability of soil aggregates, which perfrom to an increases soil bulk density, surface peeling, reduced porosity, water movement and retention within the soil (Ahmed et al.,2018).

The mean weighted diameter (MWD) decreases after plowing by 20% of its value before plowing, and its decrease is an important factor in pulverization the soil and its susceptibility to air erosion, the mean weighted diameter decreases from its values after plowing compared to what it was before plowing, as a result of the improvement that occurred in some physical characteristics of the soil, especially the saturated hydraulic conductivity and bulk density.

There are not enough studies on sprinkler irrigation in southern Iraq, particularly in clay soils. The goal of the study is to determine how operational pressure, moisture depletion, and soil pulverization affect mean weight diameter (MWD) in heavy clay soil, in order to address the issue of water scarcity, minimize irrigation water loss, and maintain good soil structure.

2. Materials and Methods

A field experiment was carried out at the College of Agriculture - University of Basra at the Karma Ali site in Basra Governorate during the agriculture time 2020-2021 in classification of clay soil according to Tab. (1), the results in some physical and chemical features from the soil of the research region, which was characterized using the techniques outlined in (Black et al.,1965) and (Page et al.,1982), as Clayey mixed, calcareous hyperthermic typic tornado (Al-Atab, 2008).

Study factors include:

1. The operating pressure with three treatment: 150 kPa (P1), 250 kPa (P2) and 350 kPa (P3). operating pressure was controlled by a pressure gauge and globe valves associated with each sprinkler and at the pump's primary pipe connection.
2. Two treatments are used for the moisture depletion: M1 treats the depletion at 75% of the available water, and M2 treats the depletion at 50% of the available water.

3. The two treatments for the soil pulverization grade are pulverization of the soil after one tilling (C) and pulverization of the soil three times (S). The soil is pulverized using disc harrows.

Three replications of a randomized complete block design (R.C.B.D.) were used in its execution. The experimental block was divided into three blocks, each of which was further divided into twelve experimental units, spaced one meter apart from a pilot unit. On January 12, 2020, the field was finally ready and barley seeds were sown. A total of 100% of the field capacity value was used to irrigate the experimental field using germination irrigation, with an additional 20% of the irrigation water added to meet the need for salt washing.

Tab. 1: Soil physical and chemical characteristics, depths (0–15), (15–30), (30–45) cm, and salinity of irrigation water during plant growth stages

Properties	Units	soil depth (cm)		
		0-15	15-30	30-45
Sand	$g\ kg^{-1}$	172.657	137.324	123.453
Silt	$g\ kg^{-1}$	316.513	317.746	327.026
Clay	$g\ kg^{-1}$	510.830	544.930	549.521
Texture	———	Clay	Clay	Clay
Particle density	$Mg\ m^{-3}$	2.621	2.623	2.623
Bulk density	$Mg\ m^{-3}$	1.299	1.321	1.343
Total porosity	%	50.438	49.637	48.799
W H C	%	54.230	56.500	53.320
Field capacity	%	32.876	34.985	33.569
Mean weight diameter	mm	0.203	0.192	0.155
CEC	$Cmol\ kg^{-1}$	28.355	29.105	28.410
Ca^{++}	$mmol^{-1}$	25.130	29.170	29.255
Mg^{++}	$mmol^{-1}$	21.715	23.130	21.520
K^{+}	$mmol^{-1}$	1.340	1.745	1.575
Na^{+}	$mmol^{-1}$	60.010	67.175	70.050
CO_3^{--}	$mmol^{-1}$	0.00	0.00	0.00
HCO_3^{-}	$mmol^{-1}$	1.340	1.225	1.095
Cl^{-}	$mmol^{-1}$	109.675	135.425	154.030
SO_4^{--}	$mmol^{-1}$	17.913	19.691	22.753
EC_e	$dS\ m^{-1}$	18.670	18.720	20.155
pH	———	7.470	7.450	7.654
Ground water depth	m	1.25		
Irrigation water salinity	$dS\ m^{-1}$	Beginning of the growing season	mid growing season	end of growing season
		5.13	5.13	5.13

The field was irrigated in accordance with the soil moisture depletion coefficient when the moisture content reached 75% or 50% of the total available water, according to M_1 and M_2, respectively. The irrigation water needed to be added until the seeds germinated was then determined, and after (134) days from the sowing of date, there is harvest completed on 12/4/2021. The experimental field's optional samples are collected to measure the soil moisture content's progressive decline following irrigation. Prior to each irrigation, soil samples are also collected, and the following mathematical calculation is used to determine how much water has to be added in order to bring the soil moisture content back within the field's capacity limits (USAID-Inma, 2012):-

$$W = \mathbf{A} \times \frac{\rho b}{\rho w} \times \left\{ \left(\frac{pw.fc}{100} - \frac{pw.wp}{100} \right) \times \textbf{moisture depletion} \right\} \times D \ldots (1)$$

Where is:

W: The amount of water that needs to be added to the testing apparatus (m^3). **Pw.fc:** field capacity in moisture content (w/w). **Pw.wp:** point of permanent wilting soil moisture content (w/w). **ϱb:** Soil bulk density (mg m^3). **ϱw**: Water density (mg m^3). **D:** The soil needs to be wetted to a depth of 30 cm. **A:** Experimental unit area (m^2).

The time needed to run each experimental unit's sprinkler watering system was determined using the formula below. (Hajem and Yassin, 1992):

$$T = \frac{W}{Q} \ldots (2)$$

Where is:

T: Hours of irrigation. **W:** The amount of water (in liters) added to the pilot unit.

Q: Sprinkler outage (liters $hour^{-1}$).

The weighted average diameter was estimated to be an indicator of soil aggregate stability using the wet sieving method. A wet vibrating sieving device, type Retsch AS 200, manufactured in Germany (2009). the soil samples were dried and then placed on a sieve with 8 mm diameter holes and received on a sieve. the diameter of its holes is 4 mm, and a weight of 25 g was taken from the soil sample and moistened capillary for 6 minutes, then transferred to a set of sieves for the wet sieving device, whose diameters range as follows (4, 2, 1, 0.5, 0.25) mm. After running the device for 6 min. at a vibration speed of 60 shakes min^{-1} and draining 200 ml min^{-1} of water, soil aggregates were separated from the sieves and the contents of each sieve was oven dried at 105°C, then their dry weighing was calculated and the results were expressed as the average weighted diameter (MWD) by applying the equation mentioned in Black *et al.*,(1965) as follows:

$$MWD = \sum_{i=1}^{n} \overline{Xi}Wi$$

Where is:

MWD: Weighted average diameter (mm).

$\overline{Xi}$**:** The mean diameter across all sizes of divided assemblies (mm).

Wi: Weight of leftover aggregates in a certain size range divided by the soil model's total dry weight.

The 2010 version of the statistical software Genstat DE10.3 was used to statistically analyze the data and determine the variance, interactions, and differences between the coefficients. The means were compared using the F test and the value of the least significant difference (RLSD) at the 0.05 level. Al-Qassab and Al-Mashhadani (2017).

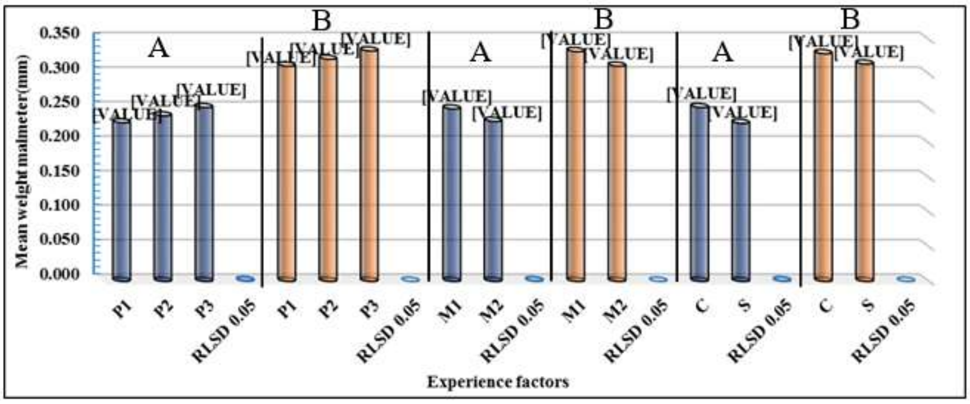
3. Results and Discussions

Fig. (1) demonstrate the operating pressure factor's significantly substantial impact on the mean weight diameter values at the beginning (A) and end (B) of the growing time. The mean weight diameter increases significantly in response to an increase in operating pressure, the Pressure P3 excellence comparison of the pressures P1 and P2 by an increase of 9.565 and 5.000% in the mid of the time and 7.051 and 3.726% at the end of the growing consecutive season, The size of the water droplets that the sprinkler produced outside decreased as the pressure was increased, as did the energy of the collision with the earth surface, which conserved the soil's structure and decreased the fractionation and collapse of soil aggregates near the soil's surface, plus an increase infiltration and moisture content, the efficiency of washing salts deeper into the soil increased with increased water movement (Chen et al.,2019).

Moreover, the fig.(1) explains it was found demonstrated the humidity depletion factor had a substantial impact on the mean weight diameter (A) and the growth end (B) values. Extreme superiority When it came to raising the mean weighted diameter, the M1 moisture depletion treatment was noticeably better values by 7.758 and 6.730% compared to the M2 moisture depletion treatment for the midpoint and final stages of the growing season, in that order. the cause of this is attributed to addition water at close intervals and close to the field capacity in treatment M1, which helped preserve soil moisture and reduce the reverse effect of repeated wetting and drying operations in breaking down soil aggregates during successive irrigations.

While in the M2 treatment, an advanced stage of moisture decline is reached, and when water is added during irrigation, the soil structure fraction and soil aggregates break down. In addition to the difference in soil electrical conductivity values between treatments M1 and M2, which negatively affects the structure of the soil and the stability of its aggregates. Moreover, evident from Fig. (1) that the values of mean weight diameter at the middle (A) and end of the growth season (B) have a substantial impact on the soil grade pulverization factor. The C pulverization once treatment recorded the greatest value mean weight diameter in the middle and end of the growing season. The soil degree effect of pulverization using disc harrows on soil moisture content, the percentage increase was 10.043 and 4.761% in the middle and late growing season, respectively, compared with the of treat S pulverization, this is due to the increase in the time of passes of pulverization large solid clods are crushed in the field equipment, resulting in the aggregates soil, and thus reduces the infiltrated soil water content during wetting and drying cycles, which was negatively reflected in the decrease in the values of the weighted diameter rate due to the high` variation in moisture content between drying period and wetting irrigation period (Altuntas and Dade,2009).

Fig. (1) Influence the effects of soil grade pulverization, operating pressure, and moisture depletion on the mean weight diameter (mm) values at the middle (A) and end (B) of the growing season



The tab. (2) It was concluded that there is a significant effect between the operating pressure factor and the effect of moisture depletion on the MWD values at the midpoint (A) and conclusion (B) of the growing season. There are principles that (MWD) Significant rise in with on the increase operational pressures varies depending on the moisture depletion treatment used. the smallest differences between P3, P2, and P1 showed the highest possible effect in the M2 treatment compared to M1, this is because to the high humidity in M1, which reduced the opposite impact of the reduction in operating pressure on the mean weighted diameter, raising the moisture content at M1, in the end of season, it becomes clear that the highest variations in the values of the mean weighted diameter of P3, P2, and P1 are in the M1 treatment compared to the M2, this is due to the to improve in soil structure in the end of the season, which rises as operating pressure rises and is reinforced by the higher moisture content supplied to the M1 treatment in comparison to with the M2, it is also due to the effect of the growth and penetration of roots in soil, Which causes the soil particles to bind and their aggregates to increase, which is reflected in the increased values of all treatments at the conclusion of the growing season as opposed to the start (Zhang et al.,2018). in general, the highest value was 0.259 and 0.348 mm in the P3 treatment with 75% M1 moisture depletion at the middle and end of the growing season, respectively, while the lowest value was 0.219 and 0.304 mm in the P1 treatment and 50% M2 moisture depletion treatment, due to the high soil salinity at This treatment reduces its humidity.

Tab. (2) MWD (mm) values at the middle (A) and end (B) of the growth season as a function of treatment between moisture depletion and the operating pressure factor

Moisture depletion / Operating Pressure	A		B	
	M_1	**M_2**	**M_1**	**M_2**
P_1	**0.241**	**0.219**	**0.319**	**0.304**
P_2	**0.249**	**0.231**	**0.332**	**0.311**
P_3	**0.259**	**0.245**	**0.348**	**0.320**
RLSD 0.05	**0.0021**		**0.0002**	

The tab. (3) shows that there is a notable impact on the values of MWD at the midpoint (A) and end (B) of the growth season of the treatment between the operating pressure factor and the soil grade of pulverization factor. the elevated in terms of the MWD with highly operating pressure differs depending on the degree of pulverization treatment, the increase differences in the MWD of P_3, P_2 and P_1 appeared in treat C compare to the treatment S, this is because to the effect of increasing the operating pressure, which is limit the kinetic energy of droplets influence on the soil's surface and raising the moisture content of the water infiltration, salts movement and salts leaching efficiency. the maximum mean weighted diameter values when treated with P_3 were 0.261 and 0.343 mm at the degree of pulverization C, while the lowest values were 0.216 and 0.305 mm when treated with P_1 at the degree of pulverization S and at the middle and end of the growing season, respectively. the reason for the low values of the mean weighted diameter at treatment P_1 and at the degree of pulverization S is due to the low uniformity coefficient for the above operating pressure and the large size of the water droplet, which has high energy when it impact with the soil surface, it causes damage to the soil surface and the dispersal of soil particles, which results in the formation of a hard crusty layer and increase bulk density that reduce the water infiltration, which makes water accumulate on the surface of the soil and increases the amount of water evaporating from the soil surface, in addition to the damage resulting from the repeated pulverization process, which fraction the primary soil clods and aggregates into very fine particles and then moves them through the soil pores of the soil, causing the soil crust and compact.

Tab.(3) The effect of the degree of soil pulverization and the operating pressure factor treatment on the MWD (mm) values at the middle (A) and end (B) of the growth season

Operating Pressure \ Grade of soil pulverization	A		B	
	C	S	C	S
P1	0.244	0.216	0.318	0.305
P2	0.252	.228	0.330	0.313
P3	0.261	0.243	0.343	0.326
RLSD 0.05	0.0021		0.0002	

The Tab. (4) (MWD) values were significantly affected by moisture depletion and grade of soil pulverzation in the mid (A) and (B) conclusion of the growing season. The benefits of pulverization therapy (C) in MWD values compared to pulverization treatment (S) is higher with moisture depletion M1 compared with moisture depletion M2. this is due to the decrease irrigation periods in treatment M1, which this increased the humidity, which led to a decrease impact energy of droplets, and increased the infiltration the profile soil, which led to an increase in the effectiveness of washing salts, treatment C has a greater impact than treatment S. (Jassim et al.,2009).

Tab.(4) The influence of treatment between the moisture depletion factor and the pulverization soil on the values of MWD (mm) at the middle (A) and end (B) of the growing season

Moisture depletion \ Grade of soil pulverzastion	A		B	
	C	S	C	S
M1	0.258	0.242	0.343	0.323
M2	0.246	0.217	0.318	0.306
RLSD 0.05	0.0017		0.0002	

The tab. (5) It demonstrates that the soil grade of pulverization factor, moisture depletion factor, and operating pressure factor all significantly affect mean weight diameter values at the midpoint (A) and end (B) of the growth season. The P3M1C therapy yielded the maximum value of 0.364 mm, while the P1M2S treatment recorded the lowest value of 0.297 mm. The table below also shows that the influence of M2 moisture depletion on the mean weighted diameter decreased as operating pressure and soil degree of pulverization C rose.

Tab.(5) The influence of the triple treatment between the influence of the grade of soil pulverization, moisture depletion, and operating pressure factor on the MWD (mm) values in the mid (A) and end (B) of the growth season

Operating pressure	Moisture depletion \ grade of soil pulverization	A		B	
		C	S	C	S
P1	M1	0.251	0.231	0.325	0.314
	M2	0.237	0.201	0.311	0.297
P2	M1	0.259	0.240	0.341	0.323
	M2	0.245	0.217	0.319	0.304
P3	M1	0.265	0.253	0.364	0.333
	M2	0.256	0.233	0.323	0.318
RLSD 0.05		N.S.		0.0003	

4. Conclusion

The increasing operating pressure to 3.5 kpa and the soil grade of pulverization (C) discounted the of reverse impact of M2 depletion on the mean weight diameter. The operating pressure P3 (350) kPa, the moisture depletion treatment M1 (75)%, and the soil pulverization degree C recorded the best results at the mean weight diameter .It is possible to reduce the reverse impact of low operating preeeure which reach to 1.5 kpa by using moisture depletion of 75% and soil pulverization treatment C.

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