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Effect of sand fractions on sandy soil –peat mixture, and irrigation intervals, infiltration rate, bulk density and grass performance in play yard

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Abstract

In sand-soil mixtures, the sand fractions mixture with peat is strongly influence the soil physical properties and the yield dry matter of turf grass in the sports field. This investigation involved to study effects of three sand fractions (0.05-1, 0.05-2 and 0.5-2) mm, depth of irrigation water (14, 18 and 22 mm) and compaction on some physical characteristics of sand-based media such (bulk density, infiltration rate and dry matter yield of turf grass. Three different sand fractions in size of sand-soil mixtures and three depths of irrigation water were prepared in which the percentage of added sand to silty clay soil was 60% by the weight. A (30cm) layer of mixture underlined by a layer of (10cm) medium gravel and 5cm coarse sand is placed in the bottom of the containers of (40 cm) diameter and 50 cm height , then cultivated with Mediterranean grass (Cynodon dactylon) using sowing rate of (35 g m^{-2}). The A factorial experiment was conducted using complete randomized design with three replicates. Mixtures were compacted daily for 60 days to simulate foot-traffic. The results showed that after compaction, sand fractions (0.05 –1) mm in comparing with other two replaced with (sand) fractions (0.05–2 and 0.5-2) mm, had adequate infiltration rate (6.20 cm hr^{-1}) to retain any intensive rainfall and the yield dry matter of grass turf significantly increased in the same treatment. The infiltration rate decreased significantly with increasing water depletion in both uncompacted and compacted treatments. Infiltration rate was at rate (2.3 cm hr^{-1}) with compaction and at the depletion of (22 mm) water depth. The results also revealed that the value of bulk density was (1.59 Mg m^{-3}), which is higher, compared to their values in the sand (0.05-2 mm) and (0.05-1 mm) which were (1.47 Mg m^{-3}) and (1.42 Mg m^{-3}) at both uncompacted and compacted, respectively.

Introduction

The sports field should provide a safe and consistent playing surface that will maintain adequate traction, surface hardness and turf grass cover, regardless to the weather conditions. The quality of playing surface is determined by a healthy, green grass, level of athletic performance and a reliable soil medium Surface. Many amendments have been used for improving soil physical properties. Sand based materials are commonly used for construction of sports turf root zones because it is cheap and more available in most locations. Sand-soil mixes have been investigated to improve the surface stability of sports field root zones [1]. Adding silt and clay to sand will increases the sand stability, but small additions of silt and clay to sand can reduce hydraulic conductivity very quickly [2].

Good drainage allows remove a large amount of water in a short period and avoids cancellation or postponement of games due to accumulation of excessive water. For the sake of drainage, many sports fields are built with sand-based root zones. Sand content and its fractions size also has been found that strongly influences Soil aeration. Sand-dominated root zones are regularly used for winter games pitches, particularly those athletic fields used by players at a professional level [3]. The relatively stable macro pores structure offers advantages of good infiltration rates and reasonable levels of air-filled pore space [4]. Harper (1978) [5] mentioned that heavy Soils like clayey soil and silt may require as much as 50-60% sand by volume for improving their resistance to compaction while retaining the firmness necessary for good playing conditions. Whereas, Taylor and Blake (1984) [6] showed that mixtures having 87%sand or more is acceptable, but this value could vary with different soil textures with different percentages of sand and clay content. There is a common agree on70% of added sand to a soil as the best rate for making sport field soil mixture [7]. But the particle distribution of this added sand is not clear or at least is not studied in Iraq. Because Kurdistan region is located in a semi-arid region that is specified by hot and dry summer, therefore irrigation is necessary. The study of optimum irrigation water quantity based on irrigation depth is required to give a good, healthy and green grass cover also to give a comfortable and moist cover for the players. Therefore this study conducted to determine a suitable sand fraction amount of water added during irrigation on infiltration rate and bulk density then its consequence effect on grass yield in the athletic field.

Materials and Methods

The soil samples were collected randomly from the football Yard from (30) cm depth of the Faculty of Agricultural Sciences/ University of Sulaimani at Bakrajow. The soil was air dried gently crushed, then sieved at 2 mm sieve and stored for subsequence use. Some chemical and physical properties of the soil were tested, (Table 1).

Table-1: Some physical and chemical properties of the studied soil at depth of (0-20 cm).

Si	C	S	ρ_b	EC	Ca^{2+}	Mg^{2+}	Na^{+}	Cl^{-}	HCO_3^{-}	CO_3^{2-}	pH
g kg^{-1}			Mg m^3	dS m^{-1}			Meq L^{-1}				
511.9	4 22	66.1	1.23	0.43	6.42	0.46	1.1	0.14	4.4	0	7.9

From commercial building sand, three different sizes of sand particles were separated, which were ((0.05-1, 0.05-2 and 0.5-2) mm. From these three sand fractions, sand-soil peat mixture was prepared in which the percentage of added sand by weight were 60%, for each mixture 10% by volume peat moss was added. Three levels of irrigation were also established as irrigation treatment, the irrigation treatments were calculated on the base of added water as depth of water (14, 18, and 22) mm, these depths of water were calculated on the base of the rate of evapotranspiration (ET_o=7mm day^{-1}), which was obtained from the Metrological Station at Bakrajow, Particle size distribution was determined by pipette and sieving methods according to the methods described by [8].

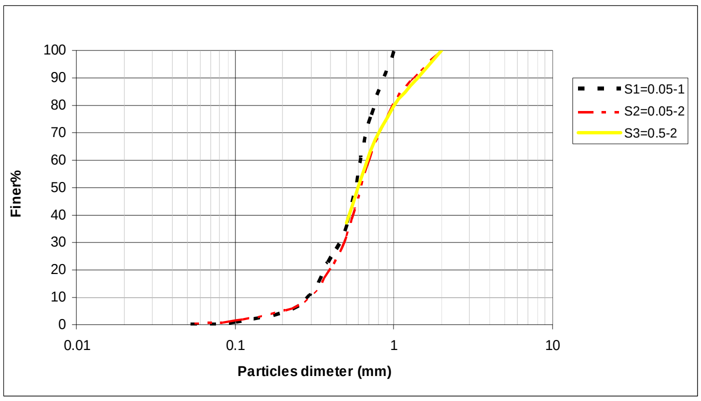


Figure -1: The particle size distributions of three sand fractions.

The bulk density of the compacted soil was calculated from the oven-dried equivalent mass of the soil and the measured volume of the soil by core method according to [8]. Porosity was measured according to method described by [9]. The sand soil- peat mixture was placed in metal containers of 40 cm diameter and 50 cm height which were provided with drainage ports at the bottom. A layer of 10 cm gravel medium was placed in the bottom of the containers as a drainage layer. Then a layer of 5cm coarse sand was used as blending layer to prevent the passage of fine particles into the gravel layer. The mixtures were moistened to give 10-15% moisture and packed into the containers up to 30 cm height. A commercial fertilizer with N: P: K (18:18:18) was used at the rate of 162.6 mg kg soil mixture and mixed with the upper 10 cm of the mixtures [7].The mixtures in the container were seeded with Mediterranean grass (*Cynodon dactylon*) at the rate of (35 g m^{-2}); the containers were designated as a factorial complete randomized design with three replicates. The total number of experimental units was: 3 sand fractions x 3 irrigation depths x 3replicates = 27 containers.

The obtained data were analyzed statistically using factorial *complete randomized design, and the differences between treatments means were calculated using least significant differences at $P<0.05$. After establishment, the plants were irrigated every two irrigation treatments were established based on water depths (14, 18, and 22) mm. Compaction was accomplished daily and for 60 days by adding a static weight of 68 kg to a wood wedge that cover one-twelfth of the container surface giving a pressure of 650 g cm^{-2} [10]. The process of the compaction was done each time before irrigation.

The rate of infiltration was measured before and after soil compaction using double ring infiltrometer, the inner cylinder was 30 cm in diameter driven into the soil and the container wall act as an outer ring. After establishment, the grass was cut gently whenever is necessary at 5 cm height above the soil surface then collected and was placed in paper bags, air and oven dried at ^{o}C for 48-72 hours till reaching the stable weight, then the weight of dry matter of the grass were recorded.

Results and Discussion

Effect of sand fraction and irrigation depth on water infiltration rate under uncompact and compact soil:

It observe from (Figure 2) the water infiltration rate before compaction ranged from (7.20to 5.60) cm hr^{-1} sand fractions soil of (0.05-1) mm, and from (6.8 to 5.6) cm hr^{-1} in sand fraction soil of (0.05-2) mm and from (6.50 to 4.30) cm hr^{-1} in sand fraction soil of (0.5-2) mm. On the other hand, it was noticed that the water infiltration rate in compacted soil ranges from (6.20 to 4.6)cm hr^{-1} in sand fraction soil of (0.05-1) mm, from (4.80 to 3.20)cm hr^{-1}in sand fraction soil of (0.05-2) mm and from (3.40 to 2.30)cm hr^{-1} in sand fraction soil of (0.5-2) mm. there is a change in infiltration rate due to decrease in total porosity in course sand fraction and increase in bulk density, these results are in agreement with those found by [11] when they observed that the compaction caused by seed bed preparation traffic increased the bulk density to a depth of at least 30 cm. Also agreed with those found by [12] in which they reported that soil compaction decreased total porosity and water infiltration rate. It can be also inferred from (Figure 2) that there is a continuous decrease in the water infiltration rate with increasing sand fraction from (0.05-1 to 0.5-2) mm uncompacted and compacted, this may be due to the continuous increase in pore spaces and uniformity increase total porosity in fines and fraction size. The best value of infiltration rate as minimum level was (5.6 cm hr^{-1}) at the sand fraction (0.05-1) mm of uncompacted soil.

It can be observed from (Figure 3) that the water infiltration rate in uncompacted soil ranged from a (7.20 to 6.20) cm hr^{-1} from (6.20 to 5.20) cm $hr^{-1}$and from (5.60 to 4.60) cm hr^{-1} at depths of water irrigations 14, 18 and 22 mm, respectively. On the other hand, it was noticed that the water infiltration rate in compacted soil ranged from (6.50 to 3.40) cm.hr^{-1}, from (5.50 to 2.50) cm $hr^{-1}$and from (4.30 to 2.30) cm hr^{-1} at depths of water irrigations 14, 18 and 22 mm, respectively. The depth of irrigation water 14 mm treatment had a (22.2 and 25.8%) higher infiltration rate than the depth of irrigation water 22 mm treatment under sand fraction (0.05-1) mm in un compacted and compacted soils, respectively.

Agrawal *et al*., (1987) [13] observed that a slight increases in compaction increased the soil moisture retention and reduced the infiltration rate; this may be due to the filling of voids between the sand particles with soil particles. Therefore this sand proportion is considered as a threshold value. However, further increase in sand proportion beyond the threshold value caused an increase in the value of infiltration rate and the total porosity as in treatment (0.05-1) mm. In this study, infiltration rate decreased significantly with increasing irrigation depth in both uncompacted and compacted as shown in (Figure 3).Infiltration rate in three sand fractions when water depletion (14 mm) was more than (18 mm and 22 mm). The mean value of infiltration rate of the mixture presented in (Figure 3) show that the general trend is the decreasing in infiltration with increasing in the volume of added water. The results of the experiment were in agreement with the earlier findings by [14] which reported that the rate of entry of water was greatest when the soil was dry at start of watering, but it decreased as the topsoil becomes saturated.

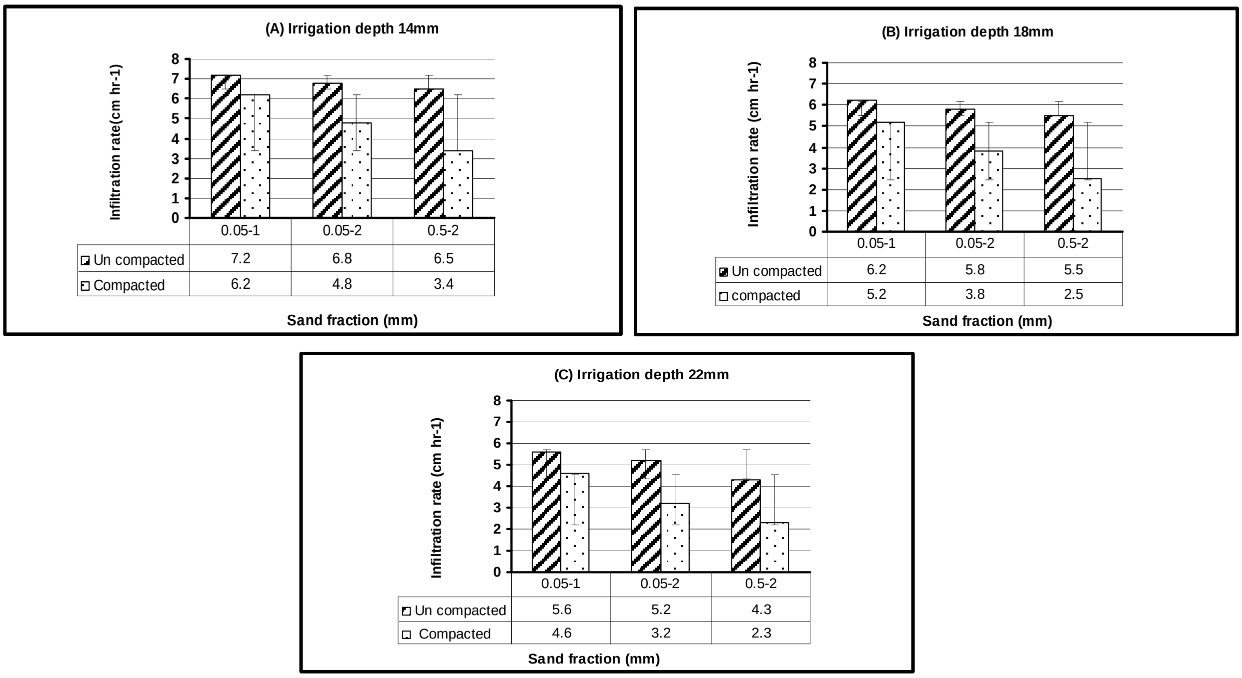
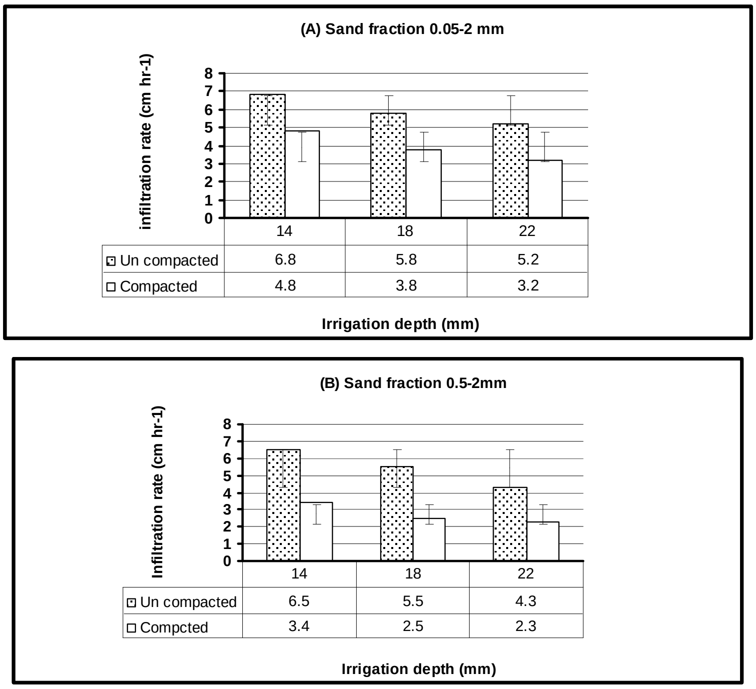


Figure -2: Infiltration rate as influenced by irrigation depth and compaction in studied sand fractions.



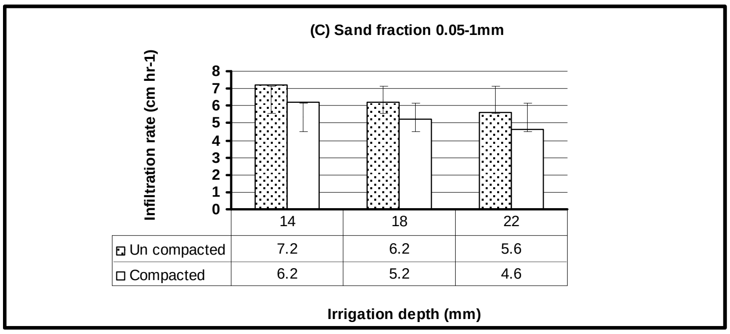
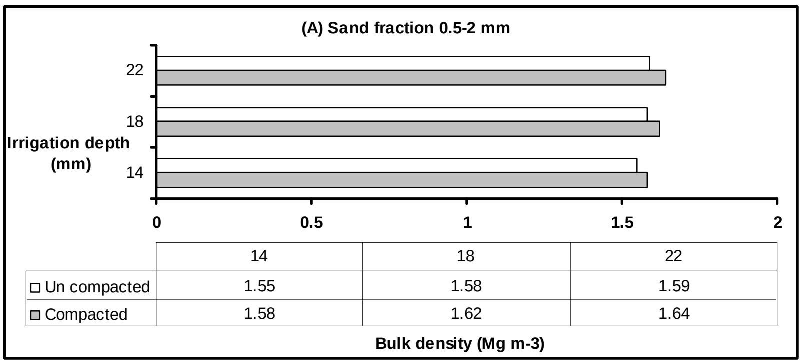
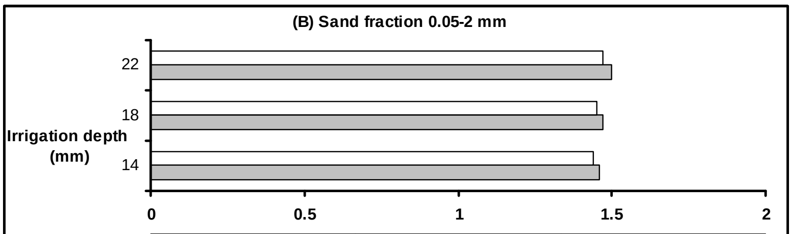


Figure-3: Replotting of infiltration rate as influenced by sand fraction and compaction in studied irrigation depths.

Relationship between the bulk density and the sand fraction:

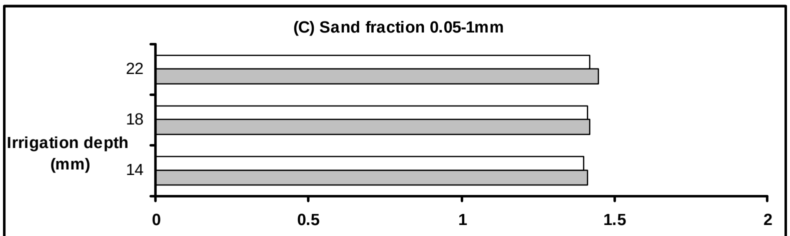
The results presented in (Figure 4) represented the relationship between the bulk density and irrigation depth at different sand fractions under two cases, uncompacted and compacted, the changes in bulk density were found from smaller to larger values. Increasing in bulk density were observed through the changes of sand fraction from fine to medium and coarse sand, with different irrigation depths and at both states of uncompacted and compacted. When the sand particles increased in size and depth of irrigation water increased, the bulk density was increased at the condition of uncompacted and similar results were recorded for compacted soil due to the smaller particles of sand caused fewer macro pores in the root zone. This was consistent with the findings of [15] when they reported that values of bulk density of soil increased with increasing level of compaction by 8 and 10 tons of farm machinery. In the study by [11] observed that compaction caused by seedbed preparation traffic increased the bulk density to a depth of at least 30 cm. Also, it appear from (Figure 4) that the maximum value of bulk density was at the sand fraction (0.5-2) mm under all irrigation depth treatments in uncompacted and compacted. The results also revealed that the value of bulk density was ranged from (1.55 to1.59) Mg m^{-3}, compared to their values in sand fraction (0.05-2) mm and (0.05-1) mm which were (1.44 to1.47) Mg m^{-3} and (1.4 to1.42) Mg m^{-3} in uncompacted, respectively. These results also agreed with the findings of [16] (Meek *et al*., 1992) they reported an increase in soil bulk density from (1.67 to 1.92) Mg m^{-3} at moisture contents near field capacity. The results also indicated that the lowest value of bulk density was 1.4 Mg m^{-3} under the irrigation depth (14 mm) where the soil treated by sand fraction (0.05-1) mm compared to bulk density values of soil treatments by sand fraction (0.05-2 and 0.5-2) mm, giving (1.44 Mg m^{-3}) and (1.55 Mg m^{-3}) uncompacted soil, respectively. The sand fraction (0.5-2) mm treatment had a (7.64% and 10.71%) higher bulk density than the (0.05-2 and 0.05-1) mm under the irrigation depth 14 mm respectively uncompacted and compacted the results of bulk density were (1.46 and 1.58) Mg m^{-3}, respectively, the reason for the significant change in the values of bulk density may be due to particle size of sand and water content, the bulk density increased with increasing soil water content more than that of increased in compacted soil. These results were in agreement those documented by [17] when noticed that sand significantly affected bulk density, with mixture composed of the finer sand packing to higher bulk densities than those composed of the coarser sand. Similar results were reported by [18] which found an increases in soil bulk density for tracked inter row areas of a controlled traffic area.





	14	18	22
Un compacted	1.44	1.45	1.47
Compacted	1.46	1.47	1.5

Bulk density (Mgm-3)



	14	18	22
Un compacted	1.4	1.41	1.42
Compacted	1.41	1.42	1.45

Bulk density (Mg m-3)

Figure-4: Bulk density as influenced by irrigation depth and compaction of studied sand fractions.

Relationship between infiltration rate and bulk density:

As shown in figure (5a), before compaction ,there was a fair correlation (R^2 = 0.4) between bulk density and infiltration rate for the three sand fractions and three irrigation depth of water, but there was a strong correlation (R^2 =0.8) after compaction (Figure 5b), this May be related that there is no uniformity in pore size distribution and pore spaces, these results are in agreement with that found by [19] when they demonstrated that sand characteristics had an impact on mixture properties after compaction of field plots.

These slow infiltration rates resulting from the high bulk densities will make irrigation difficult at a soil bulk density of (1.59 Mg m^{-3}). The long irrigation times will cause problems with turf grass that are sensitive to water logging and would require the application of small amounts of irrigation water at frequent intervals. Also, it was indicated by [17] that the bulk density and water infiltration rates of coarseness sand particles were more important than the differences in uniformity of the particle fractions of sands. As measured by uniformity coefficient (d_{60}/d_{10}), the finer sand was more uniform. Also [20] found that plant roots are important in regard to water flow through the soil when the plants were actually growing; they found that the infiltration rate was reduced because root growth blocked the channels. Later, when the roots decayed, channels were open for water flow. In this study, an increase in bulk density from (1.59 to 1.64 Mg m^{-3}) the infiltration rate measured in the field decreased by (86.96%). Similar results were found by [13] in sand soil. Turf cover, compaction and thatch all decrease the soils' intake rate, compaction during construction or even by the traffic during playing.

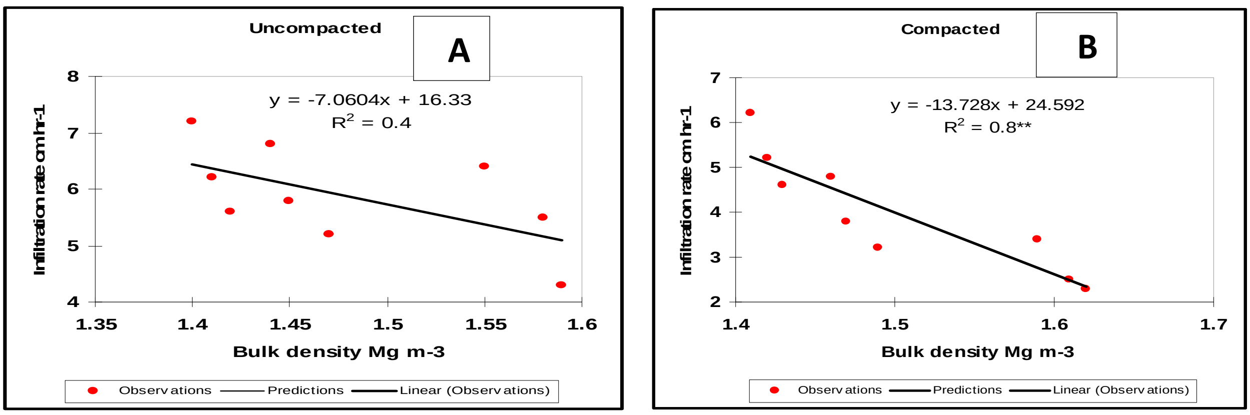


Figure -5: Relationship between bulk density and infiltration rate of studied sand fractions and at all studied irrigation depths in both uncompacted and compacted soil. **(**)** high significant

Relationship between compaction and dry matter yield

Dry matter yields of Bermuda grass (*Cymodon dactylon*) for the period of two weeks before compaction and two weeks after compaction shown in table (2). it appear that the, dry matter yield decreased with compaction in all sand fractions and at all studied depths of water irrigation. Dry matter yield was decreased with compaction from (1.96 to 1.83) %, (1.56 to 1.45) % and (1.66 to 1.56) % in sand fraction (0.05-1), (0.05-2) and (0.5-2) mm respectively. Also from the table (2) the effects of size sand texture on dry matter yield was observed in which decreased from fine sand to coarse sand texture that was ranged from the maximum 1.96 at (0.05-1) to the minimum 1.56% at (0.5-2) mm, except in the medium sand, with texture of (0.05-2) the minimum value of dry matter yield was 1.51%. Statistical analyses have shown that the dry matter yield was high significantly (F: $p < 0.05$) affected by sand fraction (0.05-2) before compaction compared with that after compaction, on contrary dry matter yield was not significantly (F: $p < 0.05$) affected by sand fraction (0.05-1) and (0.5-2) in the same conditions after compaction. these agreed with the results obtained by [21] which they found no significant yield decrease due to compaction in field, while compaction caused decreased yields in fields with two cuts on peat soils. Also Statistical analyses have shown that the dry matter yield was high significantly (F: $p < 0.05$) among the sand fraction and irrigation water depth. [Table (2)]

Table -2: Data of dry matter yield of turf grass in three sand fractions and three irrigation depth before and after compaction.

Treatments		dry matter (g pot^{-1})	
Sand fraction	Irrigation water depth	Before compaction	After compaction
mm	mm	g pot^{-1}	g pot^{-1}
(0.5-2)	14	1.56 **g**	1.28 **j**
	18	1.51 **h**	1.23 **k**
	22	1.45 **i**	1.17 **l**
(0.05-2)	14	1.66 **e**	1.56 **g**
	18	1.61 **f**	1.51 **h**
	22	1.56 **g**	1.46 **i**
(0.05-1)	14	1.96 **a**	1.91 **a**
	18	1.90 **b**	1.85 **b**
	22	1.83 **c**	1.78 **c**

Conclusions:

The infiltration rate and bulk density were affected by each of sand fractions, irrigation depth and interaction between them. The soil can be mixed with sand fraction (0.05-1) mm to increase the value of infiltration rate and increase the resistance to compaction, in the same time increase of dry matter with good health.

Recommendations:

The best recommendations that can be drawn from the results of this research is that the shape of sand that has been used was fragmented and sharp edged, it is necessary to make more investigation on round sand, as it is more available in the south of Iraq, and to see it will gives similar results. Also the soil in this experiment was silty clay but it is not necessary to obtain the same results using the soil texture.

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