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Investigation of different organic fertilizers application on the soil water holding capacity

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Abstract

This study was conducted to investigate the impacts of organic fertilizers on soil water holding capacity in four different suctions (0, 0.05, 0.33 and 15 bar) and their impacts on water retention curve in three different soil textures in five governing climates of Iran, which were cultivated under wheat and maize for two consecutive years. Furthermore, the role of organic materials in aggregation process was surveyed. The influence of organic materials on soil water holding capacity was evaluated in five treatments, including 10000, 20000 kg/ha of animal manures; 10000, 20000 kg/ha of compost, and control treatment in factorial and completely randomized statistical design. The results revealed that the addition of materials resulted into an increase in the mean weight diameter of soils aggregates with more concentration on 250-500 and 500-1000μ diameter. Additionally, the improvement of soil aggregation was more in sandy loam soil and less in clay loam soil. Interestingly, the role of organic materials in increasing soil water holding capacity in different plants and consecutive years was not significant. By adding organic materials in field capacity and permanent wilting point, soil volumetric moisture increased far better than other studied soil moisture points. Sandy loam texture and semi-arid climates indicated the greatest variability to the additional organic materials. In conclusion, compost fertilizer in arid and semi-arid climates with sandy loam texture had the most influence on soil water holding capacity, particularly in FC and PWP moisture points.

Keywords: Soil volumetric moisture, Soil structure, Water retention curve, Animal manure, Compost

1. Introduction

Proper management of plant residues is one of the most suitable methods in keeping and restoring soil organic matter and, consequently, soil water content in several regions of Iran, which face serious water scarcity. Organic matter is the best amendment in many arid and semi-arid regions of the world in order to increase soil water holding capacity and improve the soil physical characteristics (Yazdanpanah *et al.,* 2013).

Soil organic matter plays a pivotal role in long term soil conservation and/or restoration by improving the physical, chemical and biological properties of the soils (Sequi, 1989). The organic matter stabilizes soil structure by at least two different mechanisms: increasing the inter-particle cohesion within aggregates, and enhancing their hydrophobicity, thus, decreasing their breakdown, for example by slaking. More specifically, the increase in soil microbial activity, due to additional composted residues in particular, could be responsible for the increase in soil structural stability (Van-Camp *et al.,* 2004).

The long-term application of manure significantly increased the amount of macro-aggregates (>0.25 mm), yet decreased the amount of <0.053 mm aggregates in the soils of

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both, the legume-grain rotation and continuous wheat cropping systems (Lugato *et al., 2010)*, which are consistent with the observed results in a clay soil, where the additional manure significantly increased the pro-portion of macro-aggregates compared to mineral fertilizer (Hao *et al.*, 2017). Mikha and Rice (2004) reported the similar results in a conventionally tilled cropland. Zhou *et al.* (2013) also concluded that organic fertilizers could significantly improve the aggregation of soil particles compared to inorganic ones. The impacts of organic-mineral bonds as the linking factor in aggregates less than 250 µ has been approved in certain studies (Rodriguez *et al.,* 2006).

Soil water retention and plant growth response on the soil affected by continuous organic matter and plastic mulch application were investigated in a paper by Rasyid *et al.* (2018). They measured soil volumetric moisture in different suctions of pF: 2.0, 2.5, 3.0, 3.5, and 4.2 using pressure plate apparatus and concluded that the function of organic matter was continuously improving the soil water retention and plant growth environment. Water retention generally increased once the amount of adding organic matter into the soil was doubled. Moreover, the application of mesh mulch and 10 kg N ha^{-1} led to higher water retention in comparison with non-nitrogen, 40 kg N ha^{-1} or non-mulch and poly mulch.

Rawls *et al.* (2003) in an investigation titled the effects of soil organic carbon on soil water retention. They concluded that at low organic carbon contents, sandy soils have the highest sensitivity to change. The increase in organic matter content led to an increase in water retention in sandy soils and a decrease in fine-textured soils. At high organic carbon values, all soils showed an increase in water retention. The largest increase was observed in sandy and silty soils.

The effect of organic fertilizers on the water holding capacity of soil in different terrains of Jaffna peninsula in Sri Lanka was studied by Vengadaramana and Jashothan (2012). They found that a significant difference was observed in the mean water holding capacity of each soil sample with compost fertilizer and cow dung treated separately when compared to the control. Additional compost fertilizer and treated cow dung increased the mean water holding capacity of each soil sample separately. Cow dung doubly increased the water holding capacity of each soil sample.

In order to understand the controlling factors of soil water retention and discover how they affect regional eco-hydrological processes in an Alpine Grassland, thirty-five pedogenic horizons in fourteen soil profiles along two facing hillslopes in typical watersheds of Qilian Mountains on the northeast border of the Qinghai-Tibetan Plateau were selected for the study. The results showed that the extensively-accumulated soil organic matter plays a dominant role in controlling soil water retention in this alpine environment. There are two mechanisms of this controlling. Primarily, at high matric potentials, soil organic matter affected soil water retention mainly through altering soil structural parameters and thereby, soil bulk density. Secondly, at low matric potentials, the water adsorbing capacity of soil organic matter directly affected water retention. To investigate the hydrological functions of soils at larger scales, soil water retention was compared to three generalized pedogenic horizons of diagnostic surface horizon with the greatest soil water retention over the entire range of measured matric potentials (Yang, 2014).

The purpose of the current research has been classified into three parts: first, the role of organic fertilizers on aggregates formation and mean weight diameter of aggregates; second, the role of organic fertilizers application on soil water holding capacity in consecutive years of wheat-maize cultivation; and third, the role of organic fertilizers on plat available water in different soil textures and cultivations.

2. Materials and Methods

The impacts of organic fertilizers on soil physical properties have been studied on different areas of Iran based on Agro-ecological zoning (AEZ). In order to fulfil the goals of this work, we investigated 10 different case studies (Agricultural stations) with different climatic and soil physicochemical properties, including Soil and Water Research Institute of Alborz Province (35° 45' 26" N, 50° 57' 18" E), Shavoor Station Khuzestan Province (31° 50' 11" N, 48° 28' 32" E), Hassan Abad Station Fars Province (28° 47' 46" N, 54° 17' 58" E), Miandoab Station West Azerbaijan Province (36° 57' 49" N, 46° 03' 04" E), Baye' Kola Station Mazandaran Province (36° 26' 45" N, 53° 30' 59" E), Toroq Station Razavi Khorasan Province (36° 13' 16" N, 53° 40' 27" E), Kabootar Abad Station Isfahan Province (32° 31' 02" N, 51° 51' 11" E), Borujerd Station Lorestan Province (33° 40' 00" N, 48° 54' 59" E), Araghi Mahaleh Station Golestan Province (36° 54' 00" N, 54° 25' 00" E), Esmaeel Abad Station Qazvin Province (36° 15' 17" N, 49° 54' 28" E) (Fig. 1). Based on Domarton climatic classification, among the sampling sites, Lorestan and Ghazvin were classified as Mountain climate; Alborz and Fars semi-arid climate; West Azerbaijan cold and semi-arid climate; Isfahan and Khorasan Razavi arid climate; Khozestan warm and humid climate; Mazandaran and Golestan moderate and humid climate.

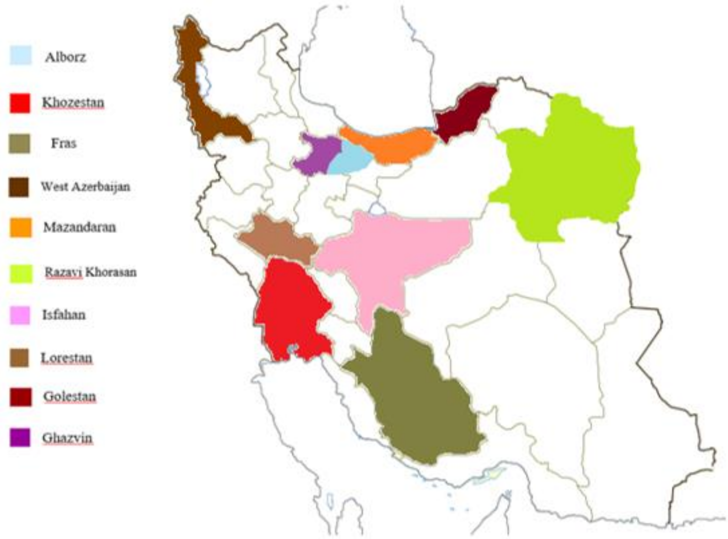

Fig. 1. The Location of sampling sites in different geographical locations of Iran

2.1. The Experimental Design

The experiment was done in fixed plots during two consecutive years cultivated by wheat-maize treated by two different organic fertilizers (compost and animal manure) and in three different amounts (0, 10000 and 20000 kg/ha) of case studies (Fig. 2).

The primary soil sampling was performed before applying the treatments to measure the physical and chemical properties of soil in natural conditions. For this purpose, we collected soil samples from 0-30 cm and carried out certain routine soil analysis, for instance soil reaction (pH), Electrical conductivity (EC), organic carbon percentage with Walkley-Black Method (Black, 1982); particle size distribution with Hydrometery (Bouyoucos, 1962); mean weight diameter (MWD) of aggregates with wet sieved method (Kemper and Rosenau, 1986); calcium carbonate percentage using calcimeter test (Nelson and Sommers, 1982); bulk density with paraffin coated clod method, and Porosity was calculated utilizing bulk density and particle density relation (Sparks *et al.,* 1996). In addition, some complementary information was collected about the fertilizers' physicochemical properties according to the protocols of Soil and Water Research Institute of Alborz Province. Undisturbed soil samples were prepared after the first and second year of wheat and maize, from experimental treatments and soil water holding capacity, was measured employing pressure plate in different water tension values, including: 0 bar (saturated soil), 0.05, 0.33 (field capacity) and 15 bar (permanent wilting point (PWP)). The determination of the mean weight diameter was done using wet sieved method. Sieved placed according to their mesh and conventional standard, respectively from 2 to 0.075 mm (2, 1, 0.5, 0.25, 0.106, 0.075 mm). Equation 1 was applied to quantify the value of mean weight diameter as given below.

$$MWD = \sum_{i=1}^{n} x_i w_i \quad (1)$$

where X_i is the mean diameter of any particular size range of aggregates separated by sieving, and W_i is the weight of aggregates in that size range as a fraction of the total dry weight of the soil used (Kemper and Rosenau, 1986). The mean weight diameter was classified in three different soil textures and 6 weight diameter ranges, including 75-105, 105-250, 250-500, 500-1000, 1000-2000 and 2000-4750.

The results obtained through different treatments were analyzed utilizing the SPSS and Excel statistical software. The significant differences observed between the treatments were checked by the analysis of variance (ANOVA). Tukey's Honest Significance Difference (Tukey HSD) and post-Hoc test was used to determine significant differences at 99% confidence level.

Fig. 2. Experimental plots cultivated by wheat-maize and fertilized with two different organic fertilizers

3. Results and Discussion

The summary statistics (basic information) of some soil physicochemical properties before applying the treatments and in different case studies is represented in Table 1. It could be clearly seen that in most cases, the analyzed soil samples were classified as slightly saline and calcic while they had low values of infiltration, cation exchange capacity (CEC) and organic matter. This proves the importance of applying organic fertilizers to amend soil physicochemical properties. Based on particle size distribution, Alborz, Khozestan, Mazandaran, Lorestan, and Ghazvin were classified in clay loam whereas Fars, West Azerbaijan, and Golestan in loam; and Razavi Khorasan and Isfahan were classified in sandy loam texture.

3.1. The Influence of organic fertilizers on Mean weight diameter of aggregates

Statistical analysis (mean comparison) of different mean weight diameter of aggregates in six different classifications and in different soil textures, respectively before and after the use of organic fertilizers, is depicted in Table 2. This comparison was done after the first and second year of cultivation to investigate the role of organic fertilizers on aggregates MWD during a long-term experiment. Meanwhile, as we found, there was only a slight change in MWD values in the second year of cultivation, which was not significant. In other words, most of the variation in aggregates MWD occurred during the first year of experiment. The data obtained from the second year of cultivation is given in Table 2.

Table 1. Descriptive statistic of some soil physicochemical properties in different case studies

Soil Properties	Unit	Alborz	Khozestan	Fars	West Azerbaijan	Mazandaran	Razavi Khorasan	Isfahan	Lorestan	Golestan	Ghazvin
Mean weight diameter	mm	0.44	0.60	0.32	0.31	0.62	0.15	0.19	0.48	0.42	0.45
Clay	%	24.52	33.18	21.86	20.45	34.62	12.10	15.40	26.83	28.20	25.10
Silt	%	27.20	36.80	27.44	25.67	38.40	22.13	28.17	29.76	35.40	27.84
Sand	%	33.28	45.02	43.71	40.89	46.98	53.77	68.43	36.41	56.40	34.06
CEC	cmol/kg	13.18	17.83	11.90	11.14	18.60	8.23	10.47	14.42	15.36	13.49
Infiltration	mm/h	9.70	13.10	12.70	11.19	13.70	17.00	21.60	10.60	16.40	9.90
OM	%	1.54	2.08	1.29	11.21	2.17	1.01	1.29	1.68	1.67	1.57
$CaCO_3$	%	10.04	13.58	12.77	11.95	14.17	11.80	15.02	10.98	16.48	10.27
EC	dS/m	4.09	5.53	4.83	4.52	5.77	6.49	8.25	4.47	6.23	4.18
pH	-----	6.24	8.44	6.93	6.48	8.81	6.58	8.38	6.83	8.94	6.39
Porosity	%	40.80	55.20	40.92	38.28	57.60	36.08	45.92	44.64	52.80	41.76
Bulk density	g/ cm^3	1.22	1.64	1.30	1.22	1.72	1.16	1.48	1.33	1.68	1.24

The obtained results revealed that most of the aggregates concentration was observed on 250-500µ (40%) and 500-1000µ (30%) for clay loam texture, 105-250µ (25%) and 250-500µ (30%) for loam texture, and finally, 105-250µ (40%) for sandy loam texture in the primary sampling and before starting the cultivation. These ranges were completely reasonable owing to the noticeable role of clay in aggregation and improving the soil structure and consequently, on improving the soil stability.

The application of organic fertilizers in sandy loam soil led into certain changes that were significantly more visible than loam and clay loam textures, in a way that the mean weight diameter in 250-1000µ considerably increased on 1% level. In clay loam texture in most cases there was no significant difference among MWD of different treatments, except the range of 500-1000µ, which implied a meaningful increase from 41 before application of organic fertilizers to 44.5 after adding 20000 kg/ha compost. In the range of 250-500µ, loam texture showed a significant decrease (about 20%) in MWD among the control treatments with 10000 and 20000 kg/ha animal manure and compost while this difference was not observed in the treatments with organic fertilizers. This difference, in range of 500-1000µ, increased from 15 in control treatment to more than 18 in organic fertilizers treatments. After adding organic fertilizers, more considerable differences were seen in sandy loam texture in MWD values in comparison with other studied soil textures. In 105-250 and 1000-2000µ we observed a meaningful decrease in MWD values whereas this parameter increased in 250-500 and 500-1000µ ranges after using organic fertilizers. For note, following different treatments of organic fertilizers, there was no significant difference between MWD values, which were influenced neither by soil texture nor aggregates concentration range.

Table 2. Mean comparison of aggregates MWD in different soil textures and organic fertilizers treatments according to their size

Texture	Treatment	75-105	105-250	250-500	500-1000	1000-2000	2000-4750
Clay loam	Control	5^a	6.5^a	31^a	41^b	11^a	5.5^a
	Animal manure 10000 kg/ha	4^a	5.5^a	31.5^a	44.5^a	10^a	4.5^a
	Compost 10000 kg/ha	4^a	5.5^a	31.5^a	44.5^a	10a	4.5^a
	Animal manure 20000 kg/ha	4^a	5.5^a	30.5^a	44.5^a	11^a	4.5^a
	Compost 20000 kg/ha	4^a	5.5^a	30.5^a	44.5^a	11^a	4.5^a
Loam	Control	7^a	20^a	31^a	22^b	15^b	5^a
	Animal manure 10000 kg/ha	6.5^a	19.5^a	25.5^b	25.5^a	18^a	5^a
	Compost 10000 kg/ha	7^a	19.5^a	25^b	25^a	18.5^a	5^a
	Animal manure 20000 kg/ha	6.5^a	19^a	25.5^b	26^a	18^a	5^a
	Compost 20000 kg/ha	6.5^a	19^a	25^b	26^a	18.5^a	5^a
Sandy loam	Control	16^a	30^a	25.5^b	13.5^b	10^a	5^a
	Animal manure 10000 kg/ha	17^a	25.5^b	28^a	15.5^a	9^b	5^a
	Compost 10000 kg/ha	17^a	25.5^b	28^a	15.5^a	9^b	5^a
	Animal manure 20000 kg/ha	17^a	25.5^b	28^a	15.5^a	9^b	5^a
	Compost 20000 kg/ha	17^a	25.5^b	28^a	15.5^a	9^b	5^a

Figures having the same letter are not statistically different ($P < 0.01$)

The role of cultivation and crop rotation on MWD demonstrated that aggregates' size ranging between 105-250 and 250-500µ found significant decrease, and between 500-1000µ showed considerable increase in the first year of cultivation, while this change did not happen in the second year of cultivation for each aggregates' size. Other aggregates range stayed rather constant after and before cultivation in all the soil textures studied in this project. Calegari *et al.* (2010) concluded that in no tillage system, the three studied soil aggregation parameters, including the mean weight diameter (MWD), geometric mean diameter (GMD) and aggregate stability (AS) index in two soil depths, increased under the no-tillage system. MWD and GMD were higher in upper layer in comparison with 10-20 cm layer. MWD increased with depth in conventional tillage system in which the soil and organic residues were incorporated into the soil. Values of MWD, geometric mean diameter and aggregate stability index were found to be lower in fall compared to winter crops; however, no significant differences were found between winter crop species. The relative enhance promoted by no-tillage compared with conventional tillage.

3.2. The Influence of organic fertilizers on soil water holding capacity

Soil volumetric moisture values obtained in the second year of wheat and maize cultivation showed no significant difference in any treatments of organic fertilizers in any sampling sites with different climatic conditions. Moreover, this insignificant difference included all the water tension values and soil textures. It seems that while in the second year of cultivation the amount of soil volumetric moisture slightly increased in every suction value, in statistics, it was ignorable. It can be due to the length of cultivation period. Every cultivation period took several months, and the impact of organic fertilizers appeared in the first year. In addition, crop rotation had a significant influence on improving the soil volumetric moisture and soil available water, which has not been investigated in this study. The role of crop type on soil water holding capacity, studied in this research, also emphasizes that no significant difference was observed in any moisture water tension among wheat and maize. In most cases, the role of maize was clearer than wheat, yet there was no statistical difference between these crops.

The results obtained by the mean comparison of different type and amount of organic fertilizers on soil water holding capacity are represented in Table 3. They illustrated that in saturated soils, which did not receive any water tension in all the soil textures, only after the application of 20000 kg/ha compost, we observed a significant increase on soil water holding capacity. At 0.05 bar water tension, respectively in clay loam and clay soil textures, after adding 10000 kg/ha compost and 10000 kg/ha animal manure the considerable increase in water holding capacity was observed, while this change was observed in 20000 kg/ha compost in sandy loam soils. This meaningful increase was not observed after adding more organic fertilizers in other treatments. In general, most of the soil volumetric moisture changes occurred in field capacity and permanent wilting point moistures, such that in field capacity of clay loam texture we observed a significant increase after adding 10000 kg/ha animal manure and this trend continued for 10000 kg/ha compost and 20000 kg/ha animal manure. The most considerable increase in soil volumetric moisture was observed in 20000 kg/ha compost and approximately, for all the studied soil textures. In permanent wilting point similar to filed capacity, we observed three different levels of soil volumetric moisture increase. They were respectively 10000 kg/ha animal manure, 10000 kg/ha compost and 20000 kg/ha compost. The obtained results verify that water holding capacity fluctuations were not dependent on soil texture after the addition of organic fertilizers. Furthermore, fluctuations of water holding capacity in filed capacity and PWP were more considerable than 0.05 bar and saturated soils, respectively.

The coefficient of variation of soil water holding capacity from saturated to wilting point for all the treatments in clay loam, loam and sandy loam moderately were 40.8, 43.8 and 46.6%, respectively. These values confirm that water holding capacity changes and the fluctuations in sandy loam were considerably more than loam and clay loam textures. In other words, the potential of sandy loam soil in increasing the volumetric moisture after using the organic fertilizers was noticeably higher compared to that of loam and clay loam textures.

The mean comparison of soil water holding capacity in three different textures, after using organic fertilizers, indicated that in most cases, particularly in FC and PWP, there were significant differences among the studied soil textures in 1% level. In all the cases, clay loam soil increased significantly more than other soil textures (Table 4). Specific area of clay loam soil in comparison with loam and sandy loam can be a factor of great importance in increasing soil organic matter and consecutively, on increasing soil water holding capacity. Clay articles had significant influences on the formation of sustainable aggregates formed by organic compounds (Denef and Six, 2005). It occurred through connection with organic molecules and unavailability of these compounds for soil microorganisms (Pronk *et al.*, 2012). In a study, Bauer and Black (1981) concluded that the impact of organic carbon on soil water holding capacity in disturbed soil samples in sandy soils was noticeable whereas in fine soil textures it was not considerable. Rawls *et al.* (2003) found that soil water holding capacity fluctuations in the presence of different organic matter values in sandy soil were more considerable than clay soil.

Table 3. Mean comparison of organic fertilizers treatments on soil water holding capacity in different moisture points and soil textures

Texture	Treatment	*%SP*	*θ1/20*	*θFC*	*θPWP*
Clay loam	Control	43.22^{b}	35.55^{c}	21.09^{d}	14.70^{a}
	Animal manure 10000 kg/ha	44.36^{b}	36.79^{c}	23.62^{c}	16.06^{c}
	Compost 10000 kg/ha	45.12^{b}	38.44^{b}	25.46^{b}	17.73^{b}
	Animal manure 20000 kg/ha	45.42^{b}	38.63^{b}	25.61^{b}	17.93^{b}
	Compost 20000 kg/ha	47.60^{a}	40.97^{a}	27.92^{a}	19.72^{a}
Loam	Control	40.81^{b}	31.61^{c}	18.71^{c}	11.87^{d}
	Animal manure 10000 kg/ha	41.89^{b}	33.05^{b}	20.18^{c}	13.94^{c}
	Compost 10000 kg/ha	42.89^{b}	34.29^{b}	22.43^{b}	15.70^{b}
	Animal manure 20000 kg/ha	42.96^{b}	34.45^{b}	22.49^{b}	15.79^{b}
	Compost 20000 kg/ha	44.64^{a}	37.19^{a}	25.08^{a}	17.37^{a}
Sandy loam	Control	36.94^{b}	29.37^{b}	16.07^{d}	9.04^{d}
	Animal manure 10000 kg/ha	38.25^{b}	30.56^{b}	18.15^{c}	11.51^{c}
	Compost 10000 kg/ha	39.62^{b}	32.05^{b}	20.81^{b}	13.24^{b}
	Animal manure 20000 kg/ha	39.68^{b}	32.46^{b}	20.95^{b}	13.42^{b}
	Compost 20000 kg/ha	41.67^{a}	34.98^{a}	23.63^{a}	15.01^{a}

Figures having the same letter are not statistically different ($P < 0.01$)

3.3. The Role of climate

Soil water holding capacity was compared in different experimental sites with different textures after using the organic fertilizers in different moisture tensions (Figs. 3 and 4). It is noteworthy that the sampling sites of Khuzestan, Mazandaran, Qazvin, Lorestan and Alborz Provinces were found as clay loam; Golestan, Fars and West Azerbaijan as loam, and Isfahan and Razavi Khorasan were sandy loam.

The obtained results shed light to the fact that saturated soils and 0.05 bar tension point did not have any influence on soil water holding capacity after using organic fertilizers in clay loam and loam textures of different studied sites. Following the addition of 20000 kg/ha compost in loamy soil, soil water holding capacity in Fars Province increased up to 26.48%, which was more noticeable than Golestan and West Azarbeijan, respectively with 25.19% and 23.56%. The coefficient of variation in permanent wilting point of both clay loam and loam soils was more than other moisture tensions. In clay loam soils, Lorestan and Ghazvin Provinces, in most of organic fertilizers treatments, showed less volumetric moisture than other studied sites. Among other sampling sites, mostly we did not observe any significant difference in soil water holding capacity in PWP. In loamy soil, the data trend was slightly different. In most of the treatments, particularly after adding organic fertilizers, soil volumetric moisture seen the highest and lowest amount, respectively in Fars and West Azerbeijan Provinces at 99% confidence level. It seems that among the case studies, Lorestan and Ghazvin Provinces, with mountain climate, showed less volumetric moisture in clay loam texture, and Fars and West Azerbeijan Provinces, respectively with semi-arid and cold semi-arid climate, had the most and least volumetric moisture in loamy soils. It is noteworthy that Isfahan and Khorasan Razavi Provinces were omitted from this comparison since they were simultaneously located in arid climate and had sandy loam texture.

Table 4. Mean comparison of soil water holding capacity after using the organic fertilizers treatments in different soil textures

Treatments	Texture	*%SP*	*θ1/20*	*θFC*	*θPWP*
Control	Clay loam	43.22[a]	35.55[a]	21.09[a]	14.70[a]
	Loam	40.81[b]	31.61[b]	18.71[b]	11.87[b]
	Sandy loam	36.94[c]	29.37[b]	16.07[c]	9.04[c]
Animal manure 10000 kg/ha	Clay loam	44.36[a]	36.79[a]	23.26[a]	16.06[a]
	Loam	41.89[b]	33.05[b]	20.18[b]	13.94[b]
	Sandy loam	38.25[c]	30.56[c]	18.15[c]	11.51[c]
Compost 10000 kg/ha	Clay loam	45.12[a]	38.44[a]	25.46[a]	17.73[a]
	Loam	42.89[b]	34.29[b]	22.43[b]	15.70[b]
	Sandy loam	39.62[c]	32.05[b]	20.81[c]	13.24[c]
Animal manure 20000 kg/ha	Clay loam	45.42[a]	38.63[a]	25.61[a]	17.93[a]
	Loam	42.96[b]	34.45[b]	22.49[b]	15.79[b]
	Sandy loam	39.68[c]	32.46[b]	20.95[c]	13.42[c]
Compost 20000 kg/ha	Clay loam	47.60[a]	40.97[a]	27.92[a]	19.72[a]
	Loam	44.64[b]	37.19[b]	25.08[b]	17.37[b]
	Sandy loam	41.67[c]	34.98[c]	23.63[c]	15.01[c]

Figures having the same letter are not statistically different ($P < 0.01$)

Climatic conditions affected certain properties, for instance soil temperature, soil water content, aeration and consequently, soil water holding capacity and water content.

Checking the coefficient of variation of soil volumetric moisture after the application of the organic fertilizers proved that this coefficient was considerably increasing from saturated soil to permanent wilting point. The maximum of coefficient of variation for soil volumetric moisture in saturated, 0.05 bar, FC and PWP were respectively 0.05, 0.08, 0.17 and 0.23. Furthermore, concerning the total and in the most moisture tensions, after adding organic fertilizers, the most and the least variation of soil volumetric moisture belonged to Khorasan Razavi, Fars and Alborz, and Lorestan, respectively. The obtained results approved that following the application of the organic fertilizers, more variation on soil volumetric Drought and high temperature increased the aerobic decomposition and as a result, accelerated the omission of carbon dioxide from soil to atmosphere (Mastrorilli *et al.*, 2015). moisture was observed in arid to semi-arid climate compared with mountain climate.

Semi-arid regions revealed the highest sensitivity to climate change (Frances *et al.*, 2016). On the other hand, microbial activity, decomposition of organic carbon and the release of carbon dioxide by microbial respiration increased with the increase in the temperature (Knorr *et al.*, 2005; Davidson and Janssens, 2006).

Interestingly, there was no significant difference between 10000 and 20000 kg/ha compost and animal manure on increasing soil water holding capacity in different moisture points.

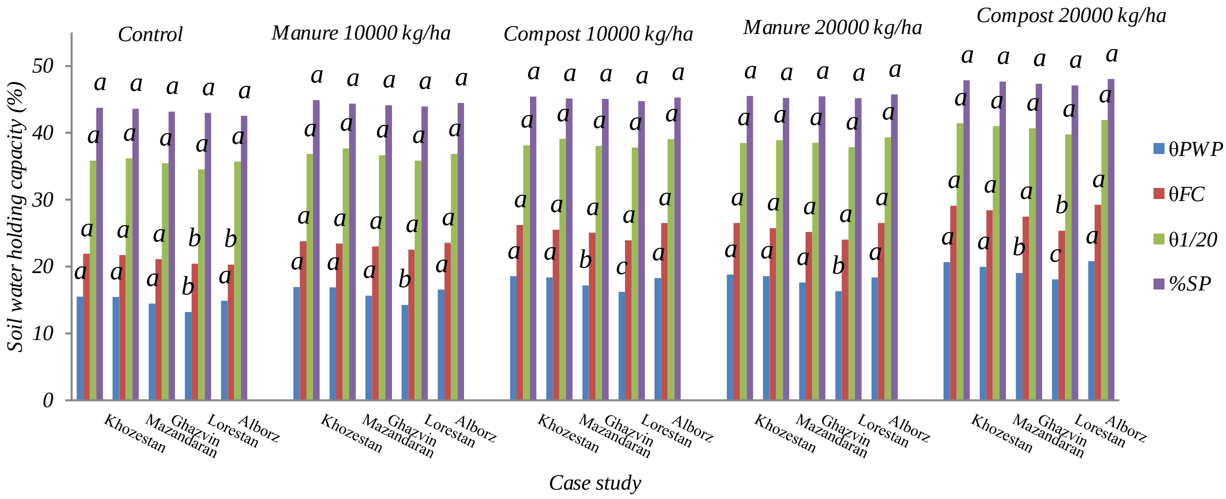

Fig. 3. Soil water holding capacity changes of clay loam soils in different case studies after applying the organic fertilizers

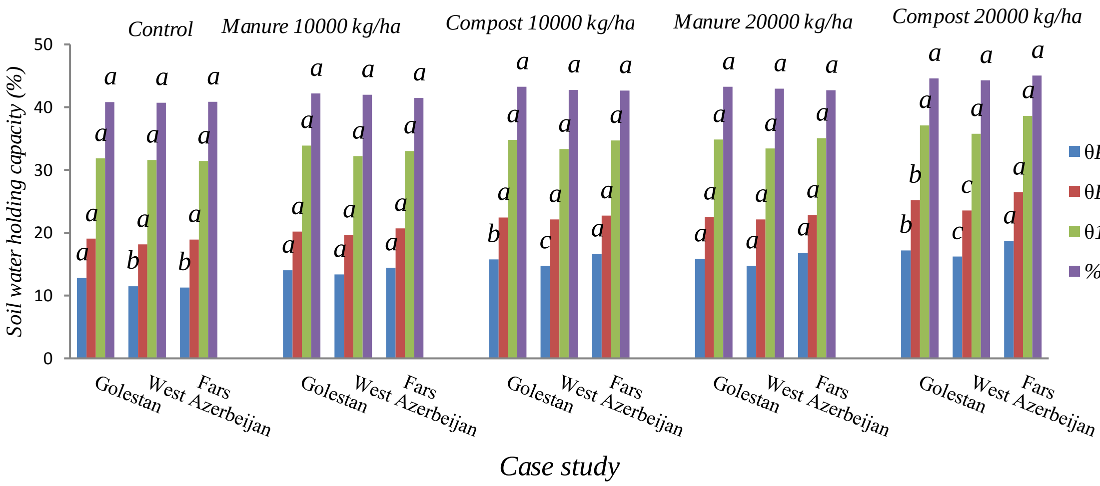

Fig. 4. Soil water holding capacity changes of loam soils in different case studies after applying the organic fertilizers

3.4. The Plant available water

The plant available water showed a noticeable increase in all the experimental sites with clay loam texture after inserting 10000 kg/ha animal manure and 20000 kg/ha compost at 99% confidence level. This change occurred while plant available water demonstrated considerable increase in loam and sandy loam textures only after adding 20000 kg/ha compost. Increasing the plant available water in clay loam texture respectively in 10000 and 20000 kg/ha organic fertilizers in comparison with control were respectively 15% and 20%. In loam soil, after adding 20000 kg/ha compost, it increased only 12% and finally, in sandy loam texture it was 18% more than control.

According to the obtained results, the variations of plant available water in clay loam texture were more considerable than loam and sandy loam soils. In addition, most of plant available water content was observed in 20000 kg/ha compost treatment. Sushila and Gajendra (2000), in an investigation, compared the increase percentage of soil water holding capacity after inserting 20000 kg/ha organic fertilizers, including animal manure and compost. They concluded that the increase percentage of soil volumetric moisture was different from 5% in saturation point to 10% in permanent wilting point. This increase in sandy loam soil, after adding 20000 kg/ha animal manure, was equal to 1.48 and 1.68 after inserting 20000 kg/ha compost fertilizer in permanent wilting point moisture tension. Emerson (1995) concluded that sandy soil had further potential to increase the volumetric moisture in saturation and permanent wilting point compared to loamy and sandy soil, after applying the organic materials. Regardless of clay content, increasing the organic matters led to the formation of some specific materials (gel) obtained from decomposition of organic residuals and microbial secretions which increased soil water holding capacity. In addition to the soil organic carbon, particle size distribution, pore size distribution and aggregates size distribution also had significant influences on increasing water holding capacity in FC and PWP points (Wu *et al.*, 1990).

3.5. The Soil moisture characteristic curve

The soil moisture characteristic curves, was more strongly affected by soil texture. The greater clay content is, the greater water content at any particular suction arises and the more gradual the slope of the curve would be. In a sandy soil, most of the pores were relatively large and once these large pores are emptied at a given suction, only a small amount of water remains. Soil moisture characteristic curve in different tensions and soil textures indicated that soil volumetric moisture in different treatments decreased with the increase in the suction. This variation started from 48% of volumetric moisture in saturated soil to 17% in PWP of clay loam. In loamy and sandy loam soil the amount of soil volumetric moisture was changed by respectively 15-45% and 10-42% (Fig. 5).

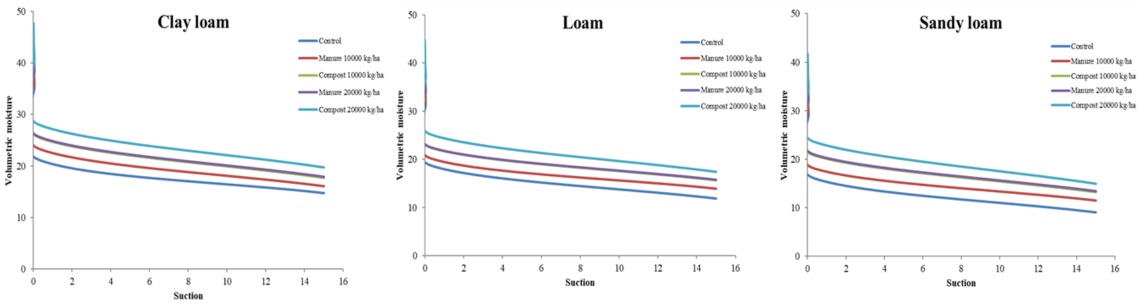

Fig. 5. Moisture characteristic curves in different soil textures

4. Conclusion

The role of applying organic fertilizers on aggregates size distribution in different soil textures led to an increase in the 500-1000µ aggregates size in clay loam, 500-1000 and 1000-2000µ in loam and 250-500 and 500-1000µ in sandy loam textures. Consecutive years of wheat-maize cultivation compared with control condition, in the first year of cultivation in particular, proved that applying the organic fertilizers caused the accumulation of aggregates with size 500-1000µ, while the accumulation of 105-250 and 250-1000µ decreased.

The influence of cultivation period and cultivation type on soil water holding capacity showed that after using different treatments, there was no considerable difference. The variations of soil volumetric moisture after using organic fertilizers (especially 20000 kg/ha compost), in FC and PWP suctions, were more significant than 0.05 bar and saturation points. Clay particles had a significant influence on increasing soil volumetric moisture content in clay loam soils, while the potential of sandy loam soils in increasing soil moisture was more notable.

The climatic effects on soil water holding capacity also demonstrated that arid and semi-arid climates were more influenced with organic fertilizers compared to mountain climates. The fluctuations of plant available water were more noticeable in clay loam than in loam and sandy loam soils, showing that the most content existed in 20000 kg/ha compost. Furthermore, plant available water in clay loam and sandy loam was higher than in loam soils in different treatments.

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