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EFFECT OF APPLICATION DIFFERENT LEVELS OF AZOLLA (*AZOLLA FILICOIDES* LAM.) IN SOME SOIL PHYSICAL PROPERTIES AND BARLEY (*HORDEUM VULGARE* L.) GROWTH INDICATORS.

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Abstract

A laboratory experiment was conducted in a pot in the vegetable canopy of the Department of soil science and water resources at the College of Agriculture, University of Basrah in soil that texture loamy sand. In order to study the adding the best level of addition *Azolla* as an conditioner in some soil physical properties and some indicators of barley crop growth. The soil was treated with *Azolla* conditioner and added at different levels: A_0 (control), A_1(0.5%), A_2(1%), A_3(1.5%), A_4(2%), A_5(2.5) and A_6(3%) with three replicates of each treatment, it was added basis on dry weight of the soil, after two months of cultivation, some of the soils physical properties were studied (mean weight diameter, bulk density, total porosity, moisture content, and saturated hydraulic conductivity) and some indicators of the growth of barley crop (plant height and shoot dry weight), and the cultivation experiment was using a complete randomized design (CRD). The results showed the improvement of the physical properties of the soil and plant growth with the addition of *Azolla* compared with control treatment, as it exceeds the level (A_3) in most of the physical properties of the soil and the characteristics of plant growth as it gave the highest values of mean weight diameter, total porosity, plant height, shoot dry weight of plant and the lowest value of bulk density. They were reached, (2.197) mm, (47)%, (51.0) cm, (5.04)g pot^{-1}, and (1.40) Mg m^{-3} respectively. Whereas, the 3% (A_7) level of *Azolla* recorded the highest soil moisture content and recorded 2.5%(A_5) treatment the lowest value of Saturated hydraulic conductivity.
Keywords: *Azolla*, Mean weight diameter, Bulk density, Total porosity, Moisture content, Saturated hydraulic conductivity and Barley plant.

Introduction

Sandy soils cover large areas of the world, covering more than 900 million hectares (Driessen *et al*., 2001). These soils have determinants when agriculturally exploited, including their reduced ability to hold and lose water beyond the root zone, which in turn leads to a decrease in the efficiency of water use and the proportion of water available to the plant Habib and Shihabi (2012), in addition to its low cation exchange capacity and its high content of calcium carbonate and its fragile and loose structure due to its lack of basic binding factors represented by organic matter due to the high temperatures and the lack of natural vegetation, which makes it high-determinant soils need to use specific administrative procedure to improve their physical, chemical and biological properties and support plant growth and production factors to achieve food security. Therefore, many researchers resorted to using multiple technologies to improve the productivity of these soils, including the technique of natural organic conditioners, whether of plant or animal origin, as these substances affect directly or indirectly in improving the structure of the soil and increase the stability of its aggregate du to the products of its decomposition through its work on collecting particles of the soil according to a clear structural system, which increases the susceptibility of the soil to water retention or by sticking the soil particles together being a binder, and therefore difficult to break down (Tarchitzky and Chen, 2002), among the aquatic plants that have desirable properties and can be used as a natural soil conditioner is the aquatic *Azolla* plant.

Azolla is an aquatic fern consisting of a short, branched, floating stem, bearing roots which hang down in the water. *Azolla* plants are triangular or polygonal in shape, and float on the surface of the water, individually or in mats. The give the appearance of a dark green to reddish carpet figure (8).

The most important feature of *Azolla* is symbiotic relationship between *Azolla* and algae as fern provides nutrients, protective cavity and other materials that promote algae growth versus atmospheric nitrogen fixation (Lumpkin and Plucknett, 1980; Van Hov and Lejeun, 1996).

Azolla has gained importance in recent years. *Azolla* is one of the aquatic plants that may be used as animal food, as green manure, biofertilizer, for increasing soil fertility, bioremediation of waste and reclamation of saline soils. Due to its high nutritional values and protein content *Azolla* is suitable for human consumption and as feed supplement for variety of animals at minimal cost (Raja *et al*., 2012). Because of the multifaceted uses the promotion and use of *Azolla–Alga* system would be ideal and environment friendly in sustainable agriculture (Yadav *et al*., 2014). Several studies indicated that adding *Azolla* to the soil improves a number of physical properties of the soil including mean weight diameter, bulk density, total porosity as well as soil moisture content of the soil. Both Subedi and Shrestha (2015) indicated that the use of *Azolla* improves soil structure when incorporated because of its high productivity, which supplies large quantities of organic matter to soil. In a pot experiment, Awodun (2008) indicated that adding different levels of *Azolla* to soil reduced the bulk density from (1.44)g cm^{-3} in the control to 1.34 g cm^{-3} in 80 g kg^{-1} soil treatment and porosity increased 6.52% over control. Bhavaneshwari and Kumar (2013) observed a laboratory experiment in sandy loam soil that adding the *Azolla* at levels 0, 10, 30, 60 and 90 g kg^{-1} soil resulted in a reduction in the bulk density of soil by 1.35, 1.31, 1.30, 1.28, 1.26 Mg m^{-3} respectively compared to the control treatment (without addition) and increased porosity of soil at the two levels 60 and 90g Kg^{-1} by (42, 41, 41, 43, 45)% respectively. Bhavaneshwari and Shahi (2016) having nine treatment namely control, *Azolla* as green manure, *Azolla* green manure (GM) + intercrops of *Azolla* (`I) , *Azolla* (GM) +50 % NPK, *Azolla* (GM) +75% NPK, *Azolla* (GM) +100% NPK, 50% NPK, 75% NPK and 100% NPK. Bulk density and water holding capacity significantly improved by the application of *Azolla* either as green manuring of intercropping. The treatment *Azolla* (GM) + *Azolla*(I) was found highly significant in increasing the water holding capacity of the soil (29.7%) and reduction in the bulk density of soil by 1.53, 1.43, 1.39, 1.41, 1.42, 1.42, 1.51, 1.50, 1.50 g cm^{-3} respectively compared to the control treatment. Betty *et al*. (2019) showed that the application of *Azolla* compost and biofertiliser increased the dry weight of rice in a saline soil.

As a result of the availability of natural soil conditioners and their cheapness as well as their accumulation in nature greatly increases the stale of pollution, So using them properly is an ideal friend of the environment and improves the physical properties of the soil therefore, this study aimed to use the aquatic *Azolla* plant as a new type of organic conditioners to improve some of the properties Iraqi sandy soil with different concentrations to determine the best possible concentration applied in the field.

Materials and Methods

Soil samples were collected from the field located at sand dune area subordinate to the district of AL-Fajer in Dhi Qar Governorate, which is located geographically between the latitude 31°54• 55.89• N and between longitude 45°56• 56.89• E and classified Coarse loamy, calcareous, hyperthermic Typic Torripsamment.

Collection and preparation of soil samples

Soil were collected from the field randomly to obtain a composite samples of depth 0-30cm. Thy were air dried and sifted through a 4mm diameter sieve then initial physical and chemical properties of the soil samples were analyzed according to Jackson. (1958), Black *et al*. (1965) and Page *et al*. (1982) and presented in table (1).

Physical properties of the soil Before Cu:

Soil Particles Size Distribution: The pipette method was used to estimate the particle sizes and described in Black *et al*. (1965).

Mean Weight Diameter: The mean weight diameter of soil was determined according to the dry sieving method. After the soil samples were dried and passed through a sieve with a diameter of 8 mm holes, it was received on a 4mm sieve, the weight of 25gm of residue on the sieve was 4mm and the samples were transferred to a group of sieves of gradual diameter (4, 2, 1, 0.5, 0.25) mm for the dry sieve device type (Endecotts test sieve shaker) English-made for 10 minutes and at a speed of 50 minutes vibration. Then the remaining clusters were weighed on each sieve and society in (pan) by applying the equation proposed by (Van Bavel, 1949; Youker and McGuinness, 1956) described in Black *et al*. (1965) by the following equation:

$$MWD = \sum x_i w_i$$

Where:

MWD: Mean weight diameter of soil (mm)

Xi: Average diameter of any volumetric range of separated aggregates (mm)

Wi: Weight of the remaining aggregates within the one volumetric range as a ratio to the total dry weight of the soil sample(gm)

Bulk Density: The bulk density was estimated from using the Core Sampler method from the following equation which was mentioned in Black *et al*. (1965)

$$P_b = ws / vt$$

Where:

P_b = Bulk density (Mg m^{-3})

ws : Weight of the dried soil sample (Mg)

vt : Total volume of the soil sample (m^3)

Total Porosity: Total porosity was calculated according to the method described in Black*et al*. (1965) by using the following equation.

$$\%f = (1- p_b / p_s) \times 100$$

Moisture Content: Determine the moisture content of the soil based on the dry weight of the soil according to the method described in Black *et al.* (1965) by using the following equation.

$$Pw = wm - ws/ ws \times 100$$

Where:

Pw = soil moisture content (%)

wm: Weight of the moisture soil sample (Mg)

ws: Weight of the dried soil sample (Mg)

Saturated Hydraulic Conductivity: The saturated hydraulic conductivity of the soil was measured by the following equation according to the method described in Black *et al.* (1965) and proposed by klute.

$$Ks = Q \times L / A \times h \times t$$

Where:

Ks: saturated water conductivity (cm hr^{-1})

Q: volume of water passing through the soil column (cm^3)

L: length of the soil column (cm). A: Surface area of soil section (cm) t: time (hours)

h: length of the soil column + the height of the water column above the soil column (cm).

Chemical Properties of the Soil Before Cultivation:

Organic Matter (OM) : The soil organic matter was estimated using the Walkley- Black method mentioned in Jackson.(1958).

Carbonate Minerals: carbonate minerals are estimated according to the method described in Jackson.(1958).

Soil pH : The degree of soil reaction in a soil water suspension was measured using a pH-Meter according to the method mentioned by Jakson (1958).

Electrical Conductivity: The electrical conductivity of the soil in the leachate was measured using the Ec-Meter and according to the method provided on page *et al*. (1982).

Soluble Cations and Anions: The positive and negative ions were estimated in the soil leachate 1:1. Sodium ions were estimated using a flam photometer as described in page *et al.* (1982). Calcium and magnesium ions were estimated to be corrected with 0.01 Na_2- EDTA standard according to the method mentioned by Jakson (1958). As for carbonate and bicarbonate ions, it was estimated by correction with 0.01N sulfuric acid as described by Richards. (1954) and the amount of chlorine by correction with 0.05 N silver nitrate. A spectrophotometer was used to estimate the sulfates after they were deposited in($BaSo_4$) by barium chloride as described in page *et al.* (1982).

Table 1 : Some initial physical and chemical properties of the soil at the depth (0-30) cm

Value	Unit	Properties	
748.20	$g\ kg^{-1}$	Sand	
101.70		Silt	
150.10		Clay	
Loamy Sand		Texture	
1.480	$Mg\ m^{-3}$	Bulk density	
2.634		Particle density	
44	%	Porosity	
17.55	%	Moisture content at field capacity	
0.097	Mm	Mean weight diameter	
14.81	$cm\ h^{-1}$	Saturated hydraulic conductivity	
1.03	$g\ kg^{-1}$	Organic matter	
162.03	$g\ kg^{-1}$	Total carbonates	
7.60		pH 1:1	
12.29	$dS\ m^{-1}$	EC	
21.45	$mmole\ L^{-1}$	Ca^{+2}	Dissolved Ions
12.66		Mg^{+2}	
38.48		Na^{+}	
6.15		-K^{+}	
0		CO_3^{-2}	
4.45		HCO_3^{-}	
53.72		Cl^{-}	
26.28		SO_3^{-2}	

Azolla collection and preparation

Aquatic *Azolla* plant was collected from the rivers of the Al- Rifai and Fajr districts in Dhi Qar Governorate, then it was air dried for 2-3days. The were crushed and packed in plastic bags for the purpose of using them in the experiment. The initial properties *Azolla* used were analyzed and presented in table (2).

Physical Properties of *Azolla*

Bulk Density: The bulk density was estimated from using the cylinder method from the following equation which was mentioned in Black *et al.* (1965)

$$P_b = m / v$$

Where:

P_b = Bulk density ($Mg\ m^{-3}$)

m : Weight of the *Azolla* sample (Mg)

v : volume of the *Azolla* sample in the cylinder (m^3).

Water Holding Capacity: A sample of *Azolla* was taken and added water to the saturation, then determine the moisture content of the *Azolla* based on the dry weight of the *Azolla* according to the method described in Black *et al.* (1965) by using the following equation.

$$Pw = wm - ws / ws \times 100$$

Where:

Pw = *Azolla* moisture content (%)

wm: Weight of the moisture *Azolla* sample (Mg)

ms: Weight of the dried *Azolla* sample (Mg)

Chemical Properties of *Azolla*

***Azolla* pH :** The degree of *Azolla* reaction in a *Azolla* water suspension was measured using a pH-Meter according to the method mentioned by Jakson (1958).

Electrical Conductivity: The electrical conductivity of the *Azolla* in the leachate(1:15) was measured using the Ec-Meter and according to the method provided on page *et al.* (1982).

Organic Carbon and Organic matter:- The organic carbon was calculated using the Walkley-Black method mentioned in Jackson.(1958),then the percentage of organic matter was calculated from the multiplied by of the carbon content in the conversion factor (1.72).

Nitrogen: Nitrogen was measured using the method presented in Jakson.(1958) using the claddal apparatus.

Phosphorus: Phosphorus was measured using the ascorbic acid method described in Jakson (1958).

Potassium: Potassium was measured using the flame photometer method described in Jakson (1958).

Table 2 : Some initial properties of *Azolla*

Value	Unit	Properties
6.33	---	PH 1:15
5.01	ds m^{-1}	EC
37.1	g kg^{-1}	N
1.1		P
12.0		K
166.0		C
4.47		C/N
286.1		O.M
0.12	Mg m^{-3}	Bulk density
552.64	%	Water holding capacity

Agricultural experience

The experiment included the use of seven different levels of *Azolla*: A_0 (0%, control), A_1 (0.5%), A_2 (1%), A_3 (1.5%), A_4 (2%) ,A_5 (2.5%) and A_6(3%) were added based on the dry weight of the soil. The soil was air-dried and sieved through a 8 mm diameter sieve. After that, the soil was mixed with added *Azolla* levels. The soil-*Azolla* mixture was added to the pots by 3 kg per pot and with three replicates for each level of addition of *Azolla*. All pots received NPK fertilization with levels 180 kg N ha^{-1}, 80kg P ha^{-1} and 150 kg K ha^{-1} (Hoshan, 2012). Than the pots were planted with barley seed class Aba 265 and by 10 seeds per pot on 15 /11/ 2018 and add water in an amount equal to the limits of field capacity for each treatment. plants dried up to five plants and after two months of cultivation (end the experiment), the plants were harvested. The soil properties and indicators of barley growth were measured at the end of the experiment, as follows:

The soil properties After Cultivation: The physical properties of the soil were measured after agriculture (end of experiment) and as mentioned above.

The plant growth indicators:

Plant height: The average height of five plants per pot at the end of the experiment was measured by measuring the height of the plant from the soil surface to the highest peak in the plant.

Dry weight of the plant: All plants per pot were harvested from the soil surface at the end of the experiment, and then dried in the oven at a temperature of 65◦ C for a period of two days to make sure the plants were completely dry, after that according to the dry weight of the plant.

The experiment was designed by using a complete randomized design (CRD). All the obtained data were subjected to analysis of variance (ANOVA) using Genstat software. Mean treatments were compared using RLSD at 5% level of probability. The results of analysis for all studied properties of soil and plant were presented in table (3).

Table 3 : Statistical analysis of the test (F)

source	df	MWD	Pb	TSP	Pw	Ksa	H.	Sh.D.W
Levels of Azolla	6	91.84**	27.47**	13.33**	285.57**	72.40**	23.31**	16.24**

MWD(Mean weight diameter of soil) P_b (Bulk density of soil), ***TSP*** (Total soil porosity), P_W (Moisture content of soil), K_S (Saturated hydraulic conductivity of soil), H(Plant height), Sh.D.W.(shoot dry weight), **(high significant).

Results and Discussion

Mean weight diameter

The results showed a high significant effect ($p < 0.01$) of the levels of *Azolla* addition in the mean weight diameter of soil (Fig.1 and tab.3)., The (A_3) treatment achieved the highest mean weight diameter of soil (2.197) mm, an increase of (546.17) % compared to the control treatment (A_0) followed by (A_6) treatment significant effect to (A_0) and (A_1) treatment, while it did not differ significantly with (A_2),(A_4) and (A_5) treatment, while (A_0) treatment gave the lowest value of mean weight diameter (0.340) mm and without significant difference with(A_1) treatment. The reason for increasing the mean weight diameter with the addition of *Azolla*, especially with (A_3) treatment, maybe due to the increase in the proportion of organic carbon in *Azolla* (Table 2), which works to link the primary soil particles with each other in micro-aggregates in addition to *Azolla* biomass plays an active role in the development of microbial population which in turn helps bind the micro- aggregates together through secretions resulting from the decomposition process in macro-aggregates, as well as increasing the ratio of organic nitrogen, organic matter and the bonding cations such as calcium and magnesium that improve the soil structure and thus increase the stability of the aggregates. These results are consistent with (Annabi *et al*., 2011; Subedi and Shrestha 2015; Alnuaymy and Alalusi, 2016). In addition to the cultivated plant roots and gum secretions they work to link the soil particles with each other, thus increasing the mean weight diameter, and this confirmed (Wang *et al*., 2016). As for the reason increase the mean weight diameter for the (A_3) treatment may be due to the improved ventilation conditions and gas exchange movement, which increases the vital activity of the organisms present in the soil and the availability of nutrients (Lakhdar 2010).

Bulk density

The results in figure (2) and table (3) showed a high significant effect ($p < 0.01$) of the levels of the addition of *Azolla* in the soil bulk density. The addition of (A_3) (1.5)% was recorded the lowest bulk density of (1.406) Mg m^{-3} an decrease of (3.23)% compared to the control treatment(A_0), followed by(A_4) treatment and significant difference from the treatment (A_6), which they did not differ significantly with (A_2) and (A_5) treatment, while the control treatment (A_0) recorded the highest bulk density of (1.453)Mg $m^{-3}$and a significant difference with the (A_1) treatment . The reason for the decrease in the soil bulk density with the addition of *Azolla* compared to the control treatment (A_0) is due to the decrease in the *Azolla* density (table 2) and its increased porosity by compared with the density of soil minerals, this in turn increases the porosity of the soil and reduces its bulk density. In addition to, the addition of *Azolla* to the soil is a source of microorganisms that in turn help to link the soil particles from during the secretions resulting from the decomposition processes that help to improve soil structure as well as the spread of plant roots and branching this in turn, increases the porosity of the soil and reduces its bulk density.

These results are consistent with (Aowden 2008; Bhuvaneshwari and Kumar 2013; Bhuvaneshwari and Shahi 2016), they showed a low bulk density of *Azolla* treated soils compared to the non-addition treatment.

Total soil porosity

Figure (3) and table (3) showed a high significant effect ($p < 0.01$) of the levels of *Azolla* addition in the total porosity of the soil, where the (A_3) treatment outperformed the highest percentage of the total porosity (47%) and percentage increase (4.44) % compared to the control (A_0) treatment and with a significant difference with other addition treatments except (A_4) treatments that did not differ significant from (A_2), (A_5) and (A_6). While the control treatment (A_0) recorded the lowest value of total porosity (45%) with significant difference with the treatment(A_1). The reason for this is due to the low bulk density of soil with the addition of the (A_3) treatment (Fig. 2) compared to the control treatment, where the total porosity is inversely proportional to the bulk density as well as the high porosity of the *Azolla* and its low bulk density (Table 2) compared to the soil minerals and this, in turn, increases the porosity of the soil. This was confirmed by (Awoden, 2008; Bhuraneshwari and Kumar, 2013; Kumar and Shahi, 2016), they found that adding *Azolla* to the soil increases the total soil porosity due to its lower bulk density.

Soil Moisture Content

The results in figure (4) and table (3) showed a high significant increase in the soil moisture content ($p < 0.01$) with increasing the level of addition *Azolla*. The highest moisture content of the soil was (20.08)% when treating the high addition (A_6) and a significant difference with other addition treatments and percentage increase (80.00) % compared to the control treatment (A_0), While the control treatment (A_0) recorded the lowest soil moisture content of (11.15)%. The reason for the increase in soil moisture content with the addition of *Azolla* may be due to the role of *Azolla* in increasing the soil's ability to hold water, as well as its porosity and high absorbability of water. In addition, the addition of *Azolla* to the soil improved the bulk density and soil porosity compared to the control treatment (A_0) (Figs. 2 and 3), this in turn increases the susceptibility of the soil to water retention and reduces the loss of moisture by evaporation, especially at high addition levels. This result is identical to the findings of Bhavanaeshwari and Shahi (2016), they showed increased the moisture content of the soil with the addition of *Azolla*.

Saturated hydraulic conductivity

Figure (5) and table (3) showed the effect of adding different levels of *Azolla* on the saturated hydraulic and lower conductivity by increasing addition levels of *Azolla*. The lowest value of the saturated hydraulic conductivity of soil was recorded with(A_5) treatment (4.91) cm h^{-1} with a significant difference with other treatments, except (A_4) and (A_6) treatment to decrease the saturated hydraulic conductivity. While the control treatment (A_0) gave the highest value of the saturated hydraulic conductivity (14.03) cm h^{-1}. Also, the results showed there was no significant difference between the (A_0) and (A_1) treatments in the saturated hydraulic conductivity. The reason for decreasing the saturated hydraulic conductivity with the addition of *Azolla* may be that the addition of *Azolla* has worked to closed and narrow the water carrying pores of the soil especially the large soil pores as a result of the difference volumetric distribution of soil pores due to the improvement of soil structure and the increase in stability of aggregates which led to increased soil retention of water and decrease in the values of the saturated hydraulic conductivity of the soil. These results were in agreement with the findings of (Dweny 2017; Demir and Dogan 2019).

Plant height

The results in figure (6) and table (3) showed significant differences ($p < 0.01$) for the levels of *Azolla* addition in the height of the barley plant. The addition of the (A_3) treatment recorded the highest height of the barley plant reached (51.00) cm significant differences with the other treatments and percentage increase of (425.77%) with the control treatment (A_0). While, the (A_4) treatment recorded the lowest height of the barley plant reached (9.7) cm and without significant difference with (A_5) treatment. The reason for the superiority of the treatment of addition (A_3) in increasing the height of the plant compared with the control treatment (A_0) and the other treatments may be attributed to the superiority of the treatment of addition (A_3) in improving most of the soil characteristics such as increased mean weight diameter, total porosity and low bulk density of soil (Figures 1, 3 and 2 respectively), which improved the favorable conditions for plant growth in terms of a balance between soil aeration and moisture, and this, in turn, positively reflected in the increase in the height of the plant. In addition to, that the addition of organic matter works to in increase the concentrations of some nutrients necessary for plant growth, such as nitrogen, phosphorous and potassium and thus improve the fertile properties of the soil, which leads to an increase in the height of plant (Das *et al.*, 2010; Amos *et al.*, 2015).

Dry weight of the plant

The results showed a high significant effect ($p < 0.01$) of the levels of *Azolla* addition in the dry weight of the plant (Fig. 7 and tab. 3). Where, the addition of the (A_3) treatment recorded the highest value of the dry weight of the plant reached (5.04) g pot^{-1} with a significant difference with other addition treatments followed by (A_2) treatment significant difference with (A_0), (A_4), (A_5) and (A_6) treatment except(A_1) treatment. While, the treatment (A_4) recorded the lowest value of the dry weight of the plant reached (0.14)g pot^{-1} without significant difference with (A_0), (A_5) and (A_6) treatment. The reason for this may be attributed to the improvement in the physical properties of the soil with the (A_3) treatment (Figs. 1, 2 and3) as well as the height of the plant (Fig. 6), which increases the spread of roots and increases the absorption of water and nutrients by the plant compared to other treatments. These results were consistent with(Das *et al.,* 2010 ; Betty *et al.*, 2019).

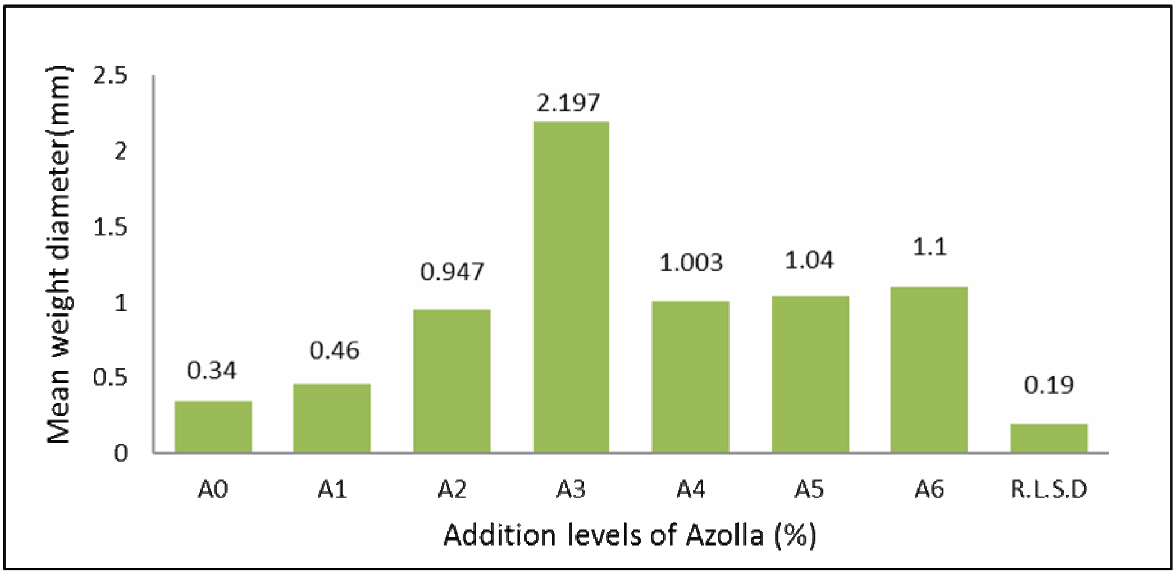

Fig. 1 : Effect of *Azolla* levels on Mean weight diameter

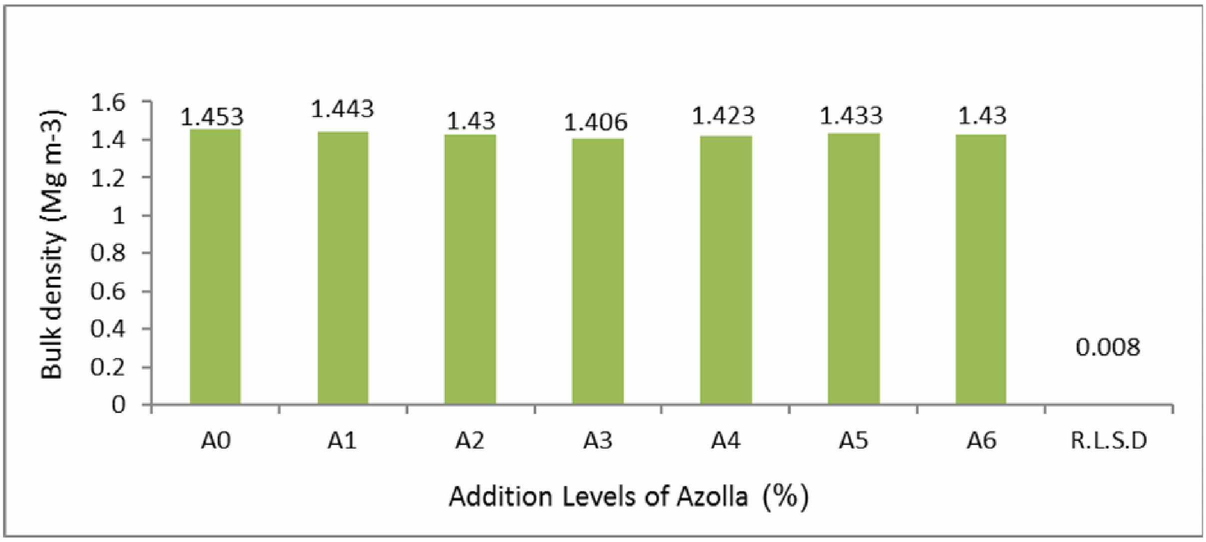

Fig. 2: Effect of *Azolla* levels on soil bulk density

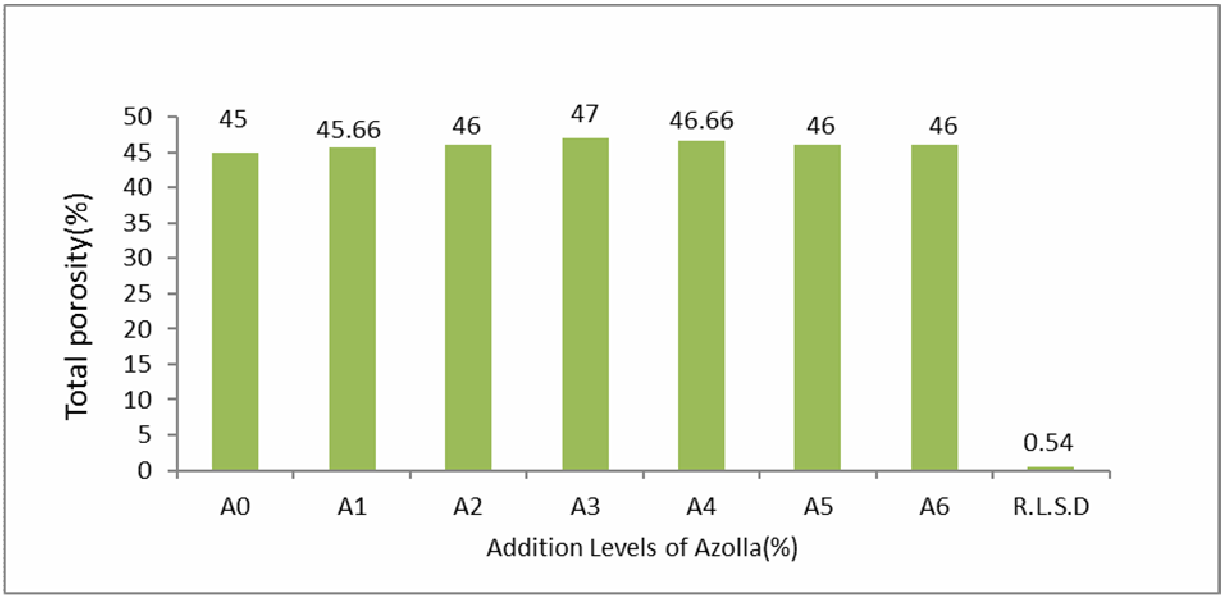

Fig. 3 : Effect of *Azolla* levels on total porosity

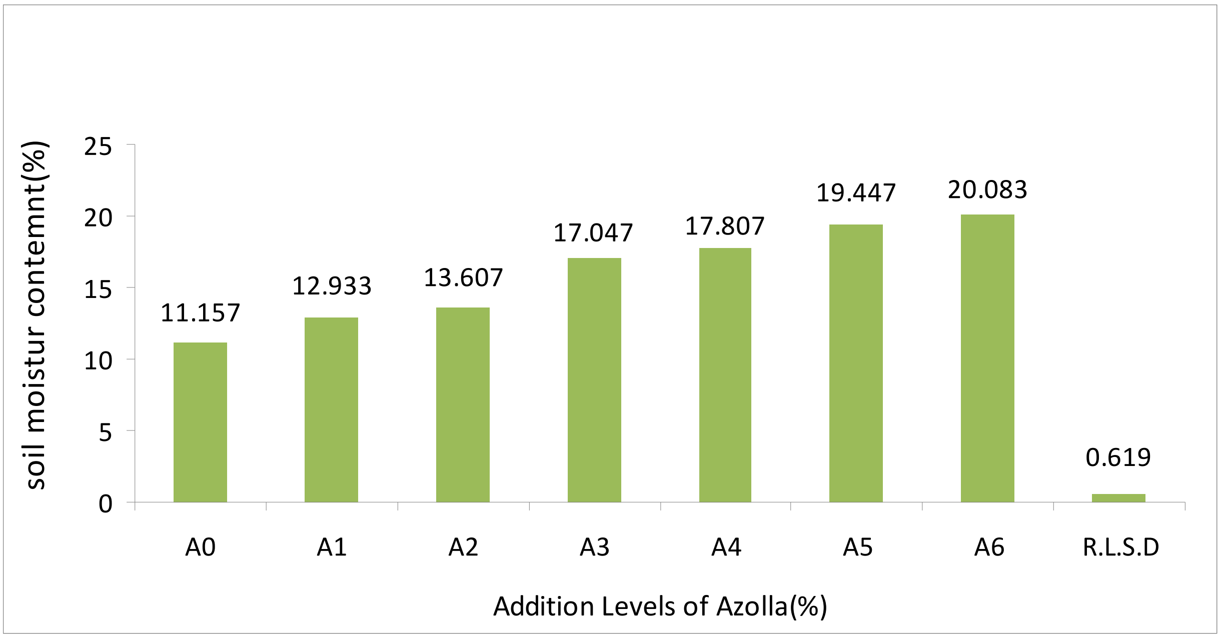

Fig. 4 : Effect of *Azolla* Levels on Soil moisture Content

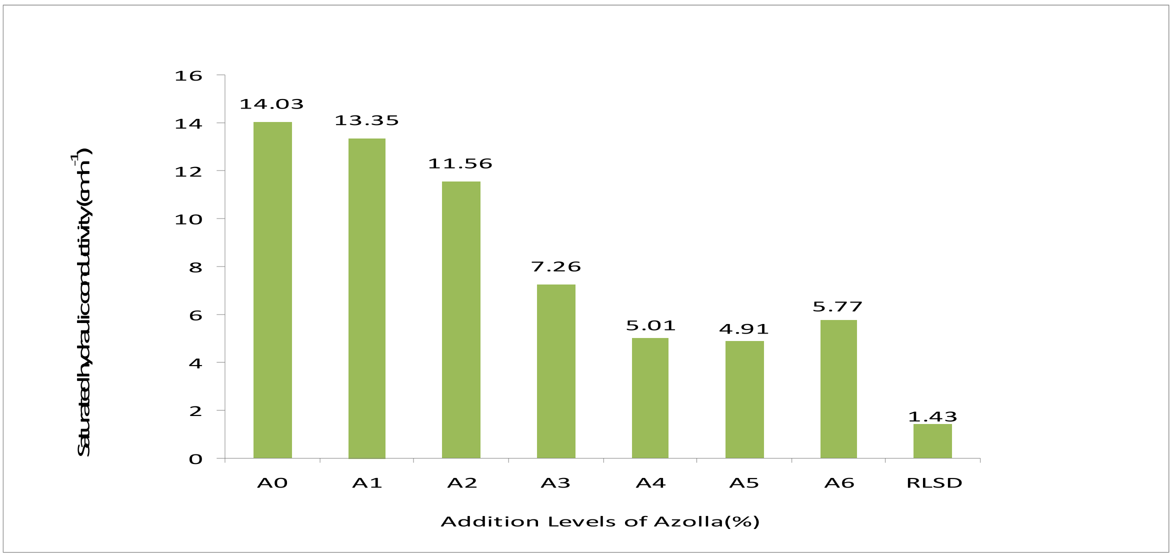

Fig. 5 : Effect of *Azolla* levels on Saturated hydraulic conductivity

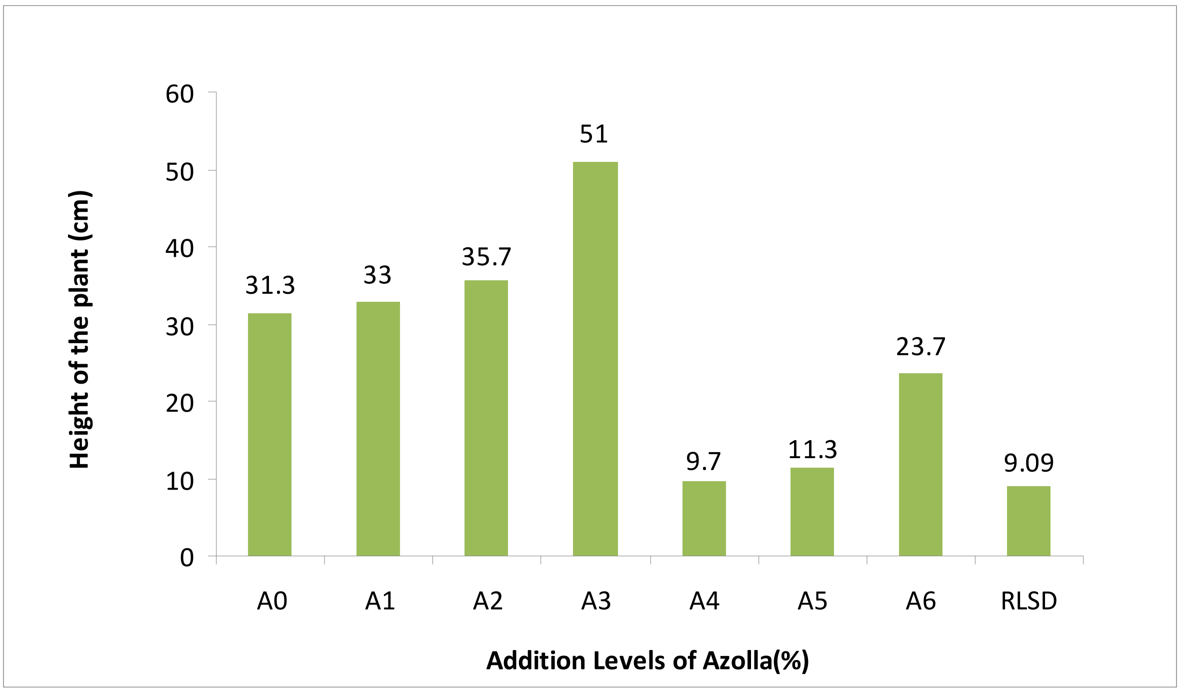

Fig. 6 : Effect of *Azolla* levels on height of barley plant

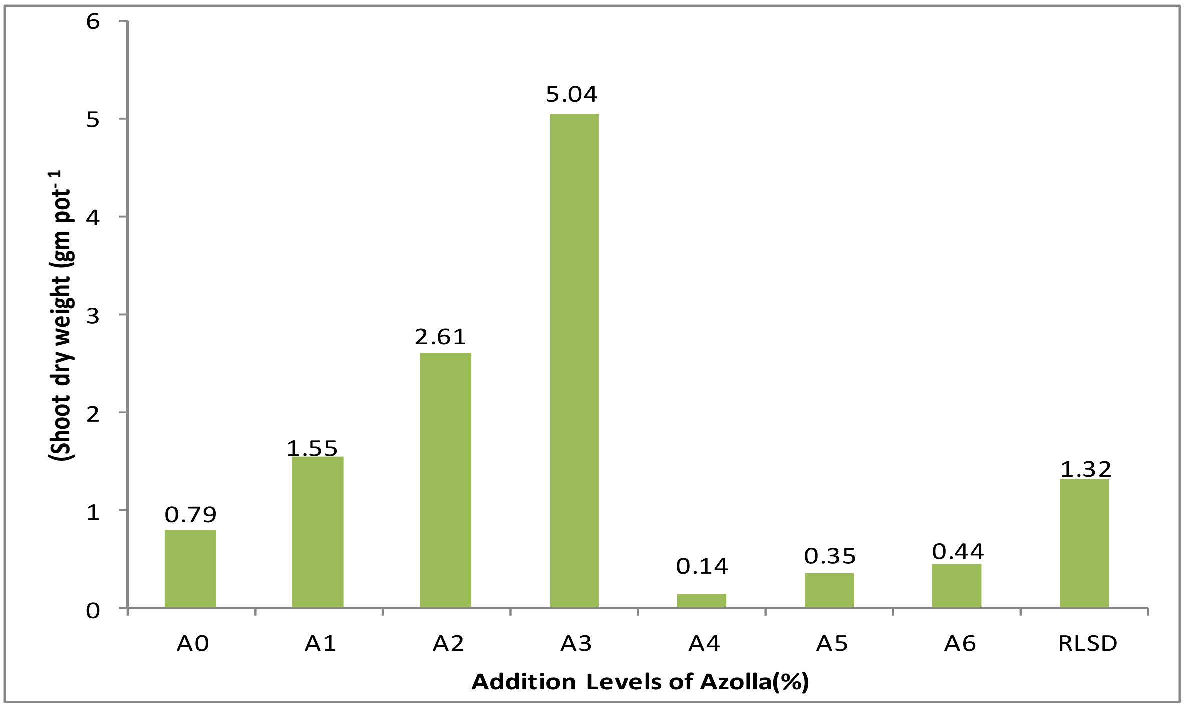

Fig. 7 : Effect of *Azolla* Levels on the Dry Weight of barley

Conclusions

We can be concluded from the results of this study that addition *Azolla* to soil has a high significant effect in improving the soil physical properties and plant growth indicators compared with the control treatment (without addition), where the addition of *Azolla* led to a decrease in the bulk density, saturated hydraulic conductivity and increase in the total porosity, the susceptibility of the soil to water retention, mean weight diameter of the soil, which was reflected in the improvement of plant growth through an increase in height and dry weight for the plant. The level of addition exceeded (1.5)% in the improvement of most of the above characteristics and recorded the highest values of height plant (51.0cm) and dry weight of plant (5.04g pot^{-1}), while the level of addition exceeded (3)% by giving the highest moisture content, but this negatively reflect on plant growth due to water logging and deflect in water – air balance. We recommend the use of *Azolla* at the level of adding (1.5)% under the conditions of the study because it has achieved most of the properties of the studied physical of soil and the growth characteristics of the barley plant.

Fig. 8 : *Azolla* in rivers of the Al- Rifai and Fajr districts in Dhi Qar Governorate

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