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The Effect of Adding Soil Amendments on Some Soil Physical Properties and the Growth of Sunflower Crop in Clay Soil

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Abstract:

The experiment was conducted in clay soil at the Agricultural Research Station affiliated with the College of Agriculture, University of Basrah, during the spring of 2021. Research aimed to study the effect of soil amendments on soil physical properties such as (bulk density, total porosity, and electrical conductivity) and some growth and yield of sunflowers such as (plant height and dry weight). The soil amendments used in the experiment were cattle manure and synthetic polymer. The amendments were added to the surface layer of the soil at a depth of 15 cm, using individual and mixed application treatments with six levels of addition (Cont, P4, O4, P3O1, O3P1, and P2O2). The field was divided into plots measuring 2.5 m in length and 1.5 m in width, and then the plots were planted with sunflower seeds. The results showed that all the amendment treatments outperformed the treatment without amendments, improving the soil's physical properties by reducing bulk density, increasing total porosity, and decreasing electrical conductivity. Additionally, the amendment treatments showed improvement in growth and yield characteristics, indicated by increased plant height and dry weight of the plants.

Keywords: soil amendments, bulk density, total porosity, electrical conductivity, plant height ,and Sunflower .

I. INTRODUCTION

Organic amendments enhance soil properties, provide nutrients for plant growth, enhance soil aggregation, stability, and water-holding capacity, and reduce soil salinity damage by reducing bulk density and improving porosity. Organic amendments also act as nutrient sources and reservoirs, enhancing plant growth and production. These amendments are crucial in improving soil health and reducing damage caused by soil salinity. Abu-Hamdeh et al. (2018) and Dahri et al. (2019) conducted studies on the physical properties of soil, including the addition of

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Polyacrylamide (PAM) and superabsorbent polymers (SAP). PAM was found to decrease the bulk density of soil and increase its total porosity, with the highest decrease and highest increase observed at 20 kg ha^{-1} and 10 kg ha^{-1}, respectively. The control treatment without addition recorded the highest bulk density rate and lowest porosity rate. Al-Mousa (2020) found that adding organic waste to soil significantly reduced the soil's electrical conductivity at the beginning and end of the wheat crop growth season compared to the treatment without addition. The results showed different values for this property depending on the type of addition. At the beginning of the growth season, the values ranged from 3.73 to 9.43 dS m^{-1}, while at the end of the growth season, the values ranged from 5.11 to 11.61 dS $m^{-1}$for the treatments (mixed, cow manure, vegetable charcoal, and without addition). Aldaoseri (2023) and Al-hilfi(2016) also studied the effect of soil amendments on clay soil. They found that adding soil amendments significantly affected electrical conductivity values, with the amendments reducing soil electrical conductivity compared to the control treatment. The compost treatment at 2% recorded the lowest electrical conductivity value of 5.86 dS m^{-1}, with a percentage decrease of 33.9% compared to the control treatment. Other treatments showed different percentages of electrical conductivity, with values of 6.49, 6.80, and 7.13 dS $m^{-1}$for the treatments of 1% compost, 0.02% polymer, and 0.01% polymer, respectively, and percentage decreases of 21%, 15.5%, and 10.2% compared to the control treatment, respectively. Muhsin et al. (2021) indicated a significant effect of organic fertilizer addition on the growth characteristics of sunflower plants. Different levels of organic manure (0, 6, 8, 10) tons per hectare were used, and their impact on growth and yield characteristics was studied. The results showed that plant height increased with increasing levels of organic fertilizer addition, with the highest plant height value of 112.98 cm. The treatment without addition recorded the lowest value of 83.58 cm. Mokgolo et al. (2019) studied the impact of adding different types of animal waste at a 20 tons ha^{-1} level on sunflower plant growth and yield characteristics during two different agricultural seasons. The study found that the growth and yield characteristics, including the dry weight attribute, improved significantly during different growth stages. The dry weight value varied depending on the type of fertilizer added, with different values recorded for each growth stage and fertilizer type. Al-Mousa (2020) found that adding organic amendments increased the dry weight of wheat crops, with the mixed organic amendments treatment recording the highest dry weight rate at 7.766 tons ha^{-1}. The increase is due to the organic amendments' role in improving soil physical properties, enhancing root growth and spread, and increasing their ability to absorb water and nutrients, leading to increased vegetative growth of plants. The study highlights the importance of organic amendments in improving plant growth and yield.

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II. MATERIALS AND METHODS

A field experiment was carried out at the Research Station of the Faculty of A field experiment was conducted at the Research Station of the College of Agriculture, University of Basrah, in the location of Karmat Ali, which is an extension of the alluvial plain, located at coordinates 20°45'47" north latitude and 30°33'30" east longitude. The experiment lasted 90 days during the spring growing season of 2021, from April 4th to July 3rd, on a land area of 1600 square meters. According to Al-Atab (2008), the soil of the experiment location is fine mixed, calcareous, and hyberthermic, typic torrifuvent. The land was divided into three equal-distance sectors. The soil was plowed using different tillage implements at depths of 15 and 30 cm .Each sector was further divided into experimental units, with 36 experimental units per sector. The experimental units were rectangular plots measuring 2.5 meters in length and 1.5 meters in width (3.75 m^2). A distance of 1 meter was left between adjacent experimental units and 2 meters between the sectors to prevent interference or lateral water movement between the sectors. The treatments were distributed in lines according to the design used. The soil amendments were randomly applied within each sector, and the amendments were mixed with the soil to a depth of 0–15 cm. Soil Conditioners: The study used two types of soil amendments: organic amendments represented by cattle manure at a rate of 2% and industrial amendments represented by the synthetic polymer polyelectrolyte at a rate of 0.02% based on dry soil weight. These amendments were mixed with the soil at a depth of 15 cm. The application treatments were distributed as follows: Treatment without conditioner (comparison treatment), (Cont), treatment added by 2% organic matter (cow residues), (O4), treatment added by 0.02% polymer, (P4), mixing treatment (25% cow residues + 75% polymer), (P3O1), mixing treatment (75% cow residues + 25% polymer), (O3P1), and mixing treatment (50% cow residues + 50% polymer), (P2O2). All sectors were planted with sunflower crops. Soil samples were collected randomly from each plot at the beginning (A) and end of the growing season (B), and their physical properties were measured. The bulk density, particle density , total porosity, particle size distribution, hydraulic conductivity, field water capacity and permanent wilting point, PH, and E.C. were determined using the method described by Black et al. (1965), while the electrical conductivity of the soil was measured according to the method proposed by Page et al. (1982). As for the plant traits, 10 random plants were selected from each plot, and their height (cm) and dry weight (Kg . ha^{-1}) were measured.

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Table (1) Physical proprieties of field experiment soil.

Soil physical properties		Soil Depths (cm)		
		0 - 15	**15 - 30**	**30 - 45**
Sand	**g kg^{-1}**	**300**	**200**	**230**
Silt		**240**	**320**	**280**
Clay		**460**	**480**	**490**
Soil Texture		**Clay**	**Clay**	**Clay**
Mean Weighted Diameter (mm)		**0.30**	**0.22**	**0.18**
Bulk density (µg m^{-3})		**1.36**	**1.39**	**1.44**
Particle Density (µg m^{-3})		**2.65**	**2.66**	**2.64**
Total Porosity (%)		**48.68**	**47.55**	**46.04**
Moisture Content (%)		**15.78**	**17.21**	**19.53**
Electrical Conductivity (ds m^{-2})		**11.08**	**10.21**	**9.74**
pH		**7.33**	**7.56**	**7.73**

Climate elements

The climate elements of the region are characterized by low rainfall in the winter and hot and humid conditions, and high evaporation rates during the summer.

Statistical analysis:

The complete randomized block design with a split-split plot was used in the experiment. The data were analyzed using the statistical software Genstat. The F-test and the least significant difference (LSD) at a significance level 0.05 were used to compare the means. T-test analysis was used to analyze the results of the beginning of the growing season (A) compared to the results of the end of the growing season (B).

III. RESULTS AND DISCUSSION

Bulk Density : The results showed a significantly high effect of the amendments addition treatment in reducing the bulk density of the soil at the beginning and end of the growing season. Figure (1) indicates the superiority of the

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amendments addition treatments over those without addition in recording a lower bulk density rate. The results also showed the significant superiority of the P2O2 addition treatment in recording the lowest bulk density rate during both growth periods compared to the comparison treatment, which recorded the highest bulk density rate. The bulk density rates were 1.245, 1.216, 1.187, 1.209, 1.176, and 1.161 Mg m^{-3} at the beginning of the growth season for the Cont, P4, O4, P3O1, O3P1, and P2O2 treatments, respectively. At the end of the growth season, the treatments recorded bulk density values of 1.311, 1.262, 1.231, 1.235, 1.224, and 1.204 Mg m^{-3} for the Cont , P4, O4, P3O1, O3P1, and P2O2 treatments, respectively. The reason behind this is attributed to the role played by organic amendments in improving soil aggregation, structure, and pore distribution, as well as increasing the growth and spread of plant roots and reducing the C/N ratio. It helps increase the activity of microorganisms, which in turn enhances the decomposition of organic matter, contributing to the improvement of soil aggregation. It works to improve the bulk density of the soil, reduce it, and increase its porosity. These results are consistent with Bladia et al. (2015), Majchrzak et al. (2016), and Akol et al. (2017). Adding polymer to the soil leads to a decrease in the bulk density of the soil and an increase in its total porosity. It is attributed to the fact that the polymer material has a lower density than the mineral matter of the soil, as well as the improvement made by the polymer in improving soil aggregation and pore size, thus reducing the bulk density of the soil and increasing its total porosity. These findings are consistent with Hou et al. (2017), Abu-Hamdeh et al. (2018), and Dahri et al. (2019).

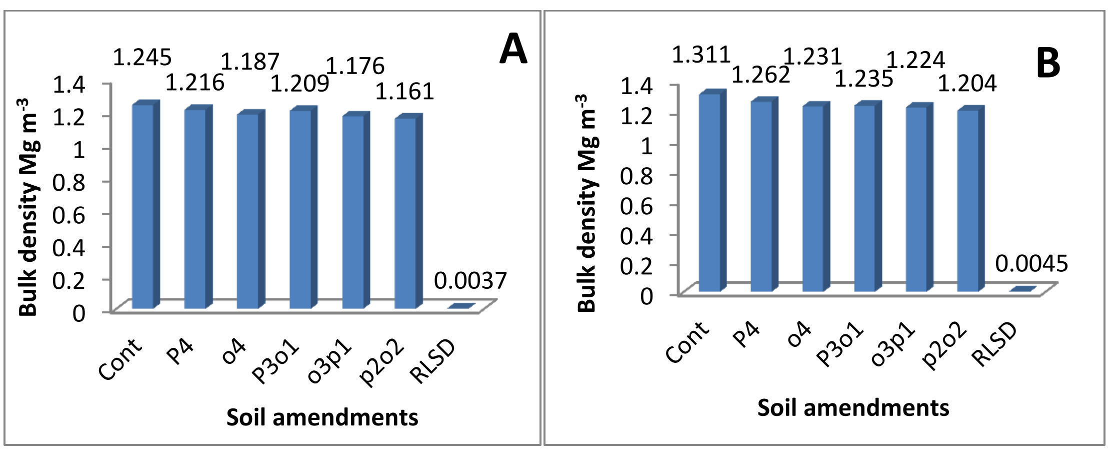

Figure (1) Effect of the type of soil amendments on bulk density of the soil at the beginning of the growing season (A) and the end of the growing season (B).

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Total Porosity :

The results showed a significant and high effect on the total porosity of adding mixed or unmixed amendments to the soil. All the amendment treatments contributed to an increase in total porosity compared to the treatment without any amendment, both at the beginning and end of the growing season. The results in Figure (2) indicated that the P2O2 amendment treatment significantly recorded the highest average total porosity for both growth periods compared to the comparison treatment, which had the lowest average total porosity due to the absence of amendments. The average total porosity values were 53.03%, 54.12%, 55.20%, 54.39%, 55.61%, and 56.18% for the treatments (CONT), (P4), (O4), (P3O1), (O3P1), and (P2O2), respectively, at the beginning of the growing season. Conversely, at the end of the growing season, the amendment treatments recorded total porosity values of 50.53%, 52.39%, 53.54%, 53.39%, 53.80%, and 54.55% for the treatments (Cont), (P4), (O4), (P3O1), (O3P1), and (P2O2), respectively. The superior performance of all the amendment treatments over the comparison treatment (no amendment) in increasing total porosity can be attributed to the role of organic amendments in improving soil aggregation, redistribution of pores, promoting root growth and proliferation, and reducing the C/N ratio. These factors help enhance the activity of microorganisms that decompose organic matter, resulting in improved soil aggregation, reduced bulk density, and increased total porosity. These findings are consistent with the studies conducted by Al-Hadeethi et al. (2010), Baladi et al. (2015), and Akoul et al. (2017). As for the polymer amendment, it contributed to improving soil structure, reducing bulk density, and increasing porosity. These results align with Abu-Hamdeh et al. (2018), who observed decreased bulk density and increased total porosity when adding PAM polymer. The decreased bulk density and increased porosity can be attributed to the polymer's lower density compared to the soil's mineral density. The polymer improves soil aggregation and pore size through its network structure, allowing it to bind soil components together, reduce bulk density, and increase total porosity. These findings are consistent with Hou et al. (2017) and Dahri et al. (2019). Malekian et al. (2012) also reported that using Pumice polymer in sandy soil resulted in a decrease in bulk density from 1.99 $g.cm^{-3}$ in the comparison treatment to 1.96, 1.5, and 1.2 g/cm^3 when adding the polymer at different concentrations of 0, 1.2, 2.4, and 3.6 $g.kg^{-1}$ of soil, respectively, attributing this to the positive effect of the polymer in redistributing fine particles and increasing porosity.

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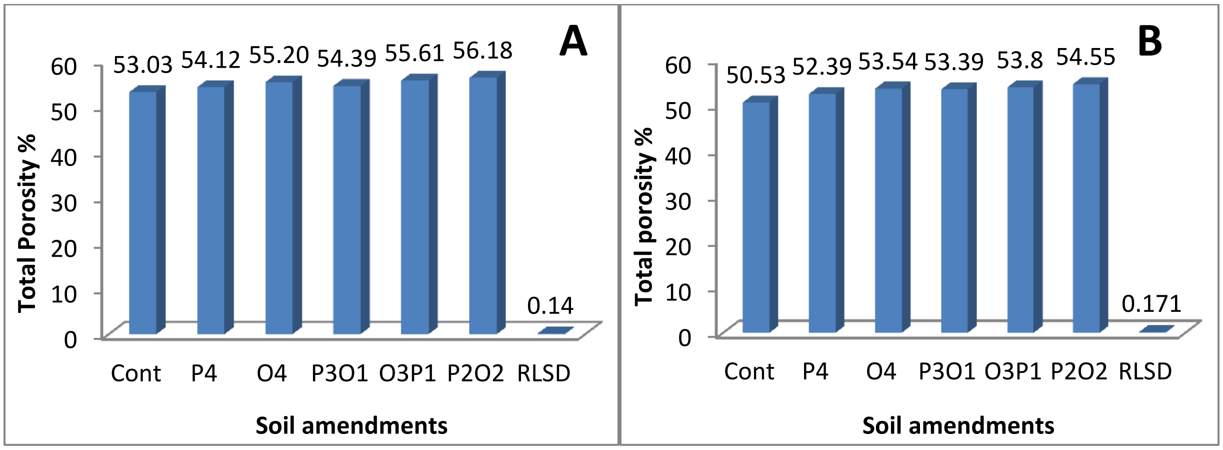

Figure (2) Effect of the type of soil amendments on total porosity at the beginning of the growing season (A) and the end of the growing season (B).

Electrical Conductivity:

The results showed soil amendments' significant and high effect on electrical conductivity for both growth periods. Figure (3) show that the mixed amendment treatment (P2O2) recorded the lowest average electrical conductivity values of 5.29 and 5.91 dS m^{-1} at the beginning and end of the growth season, respectively, compared to the comparison treatment, which recorded the highest average electrical conductivity values of 7.15 and 8.00 dS m^{-1} at the beginning and end of the growth season, respectively. The other amendment treatments (P4, O4, P3O1, O3P1) recorded average electrical conductivity values of 6.63, 6.12, 6.06, and 5.80 dS m^{-1}, respectively, at the beginning of the growth season and 6.86, 6.78, 6.92, and 6.18 dS m^{-1} at the end of the growth season. The positive effect of organic and industrial amendments in reducing electrical conductivity can be attributed to their role in improving the physical properties and soil aggregates, reducing bulk density, and increasing total porosity. It enhances the leaching of salts downward and reduces the electrical conductivity of the soil compared to the comparison treatment (Cont). These findings are consistent with the studies conducted by Muhsin (2017) and Aldosari (2023), who reported a decrease in electrical conductivity by adding organic waste to the soil, attributing it to improved soil structure and physical properties.Similarly, Al-Hilfi (2016) observed a decrease in soil electrical conductivity with the addition of a polymer amendment, attributing it to the improvement in soil structure, increased stability of aggregates, reduced bulk density, and increased total porosity, which facilitated the leaching and removal of salts away from the root zone. Tazeh et al. (2013) also found that soil treated with organic amendments (organic fertilizer and compost) resulted in a significant decrease in soil salinity by 75.03% and 65.16%, respectively, attributing the decrease to the role of organic amendments in improving the physical properties of the soil, enhancing soil structure, stability of aggregates, permeability, and overall porosity, which allows for high water

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movement within the soil profile and reduces salt movement towards the surface. It, in turn, increases the downward leaching away from the root zone, minimizing the harmful effects of irrigation salinity and preventing salt movement to the soil surface.

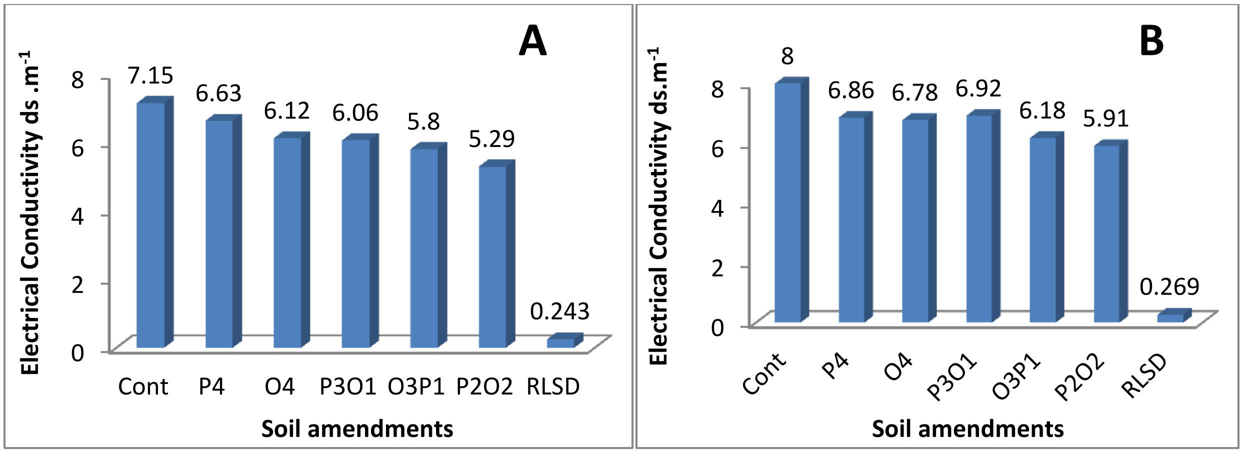

Figure (3) Effect of the type of soil amendments on electrical conductivity at the beginning of the growing season (A) and the end of the growing season (B).

Plant Length :

The results showed a significant and high effect of soil amendments on the plant length trait. Figure (4) indicates that all amendment treatments increased the average plant length compared to the comparison treatment. The amendment treatment (P2O2) performed the best, recording the highest average plant length of 150.06 cm, while the comparison treatment (Cont) had the lowest average plant length of 123.33 cm. The other amendment treatments (P4, O4, P3O1, O3P1) recorded plant length averages of 130.06, 143.56, 136.06, and 146.83 cm, respectively. The superiority of the (P2O2) treatment in achieving the highest plant length can be attributed to the combined role of both organic matter and polymer in improving the physical properties of the soil and providing favorable conditions for germination. The organic matter (cattle manure) and polymer work together to enhance soil structure, increase the stability of soil aggregates, improve aeration and permeability, facilitate root penetration, supply the soil with essential elements, and provide the plant with key nutrients such as nitrogen, phosphorus, and potassium, making them readily available for absorption by plant roots. Furthermore, the organic matter plays a role in enhancing cell division and elongation, which contributes to increased plant length. These results are consistent with the findings of Jassim et al. (2009) and Abu-Hamadeh et al. (2017), who observed improved yield and plant growth characteristics in soil amended with organic matter and polymer compared to non-amended soil. Muhsin et al.(2021) also demonstrated that the addition of organic amendments, specifically cattle manure at different concentrations,

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contributed to the improvement of growth traits and yield in sunflower plants, attributing it to the role of decomposed organic matter in releasing necessary elements for plant growth, as well as improving the physical properties of the soil.

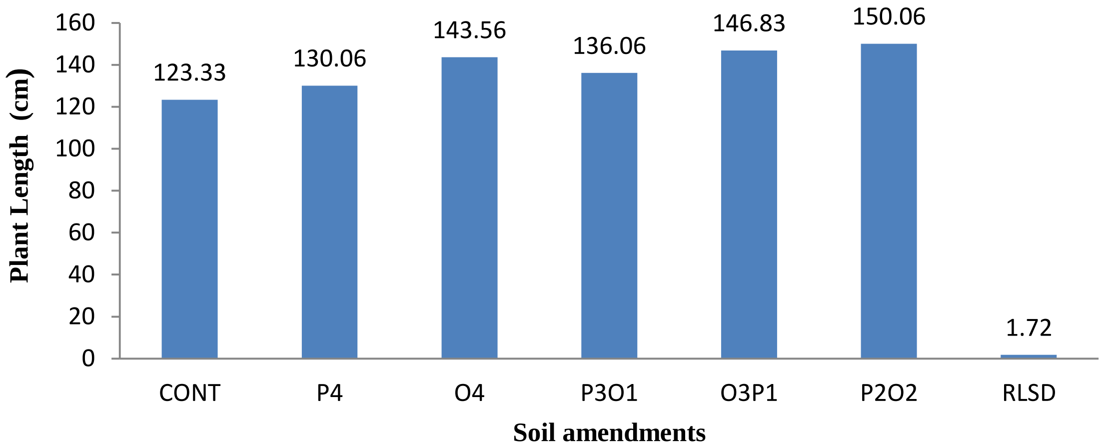

Figure (4) shows the effect of soil amendments on the plant length.

Dry Weight :

The results showed a significant and high effect of soil amendments on the dry weight of the plant. Figure (5) indicates that all amendment treatments increased the average dry weight compared to the comparison treatment. The amendment treatment (P2O2) performed the best, recording the highest average dry weight of 7475.66 $kg.ha^{-1}$, while the comparison treatment had the lowest average dry weight of 4042.76 kg ha^{-1}. The other amendment treatments (P4, O4, P3O1, O3P1) recorded dry weight averages 4707.21 5882.75, 5283.00, and 6989.78 kg ha^{-1}, respectively. The superiority of the (P2O2) treatment in achieving the highest dry weight can be attributed to the combined role of cattle manure and polymer in improving the physical and chemical properties of the soil. It includes improving soil structure, reducing bulk density, enhancing soil penetration resistance, and increasing total porosity and moisture content, which contributed to improving the growth characteristics of the crop. These results are consistent with Mokgolo et al. (2019), who observed an increase in the dry weight of sunflower crops when animal waste was added to the soil, attributing it to the higher concentration of organic carbon in the soil, which improves soil properties and provides necessary elements for plant growth. Lee et al. (2015) and Kim et al. (2015) also indicated that the polymer significantly contributed to improving growth and yield characteristics by enhancing soil structure, increasing water-holding capacity, providing sufficient moisture during the growth period, improving water-use efficiency, enhancing vertical water movement in the soil, and supplying essential nutrients such as nitrogen, phosphorus, potassium, nitrates, iron, calcium, and magnesium, which improve plant growth and productivity. As for the control treatment (Cont), it recorded the lowest average dry weight because it lacked the addition of organic amendments and polymer, which had a negative impact on growth characteristics.

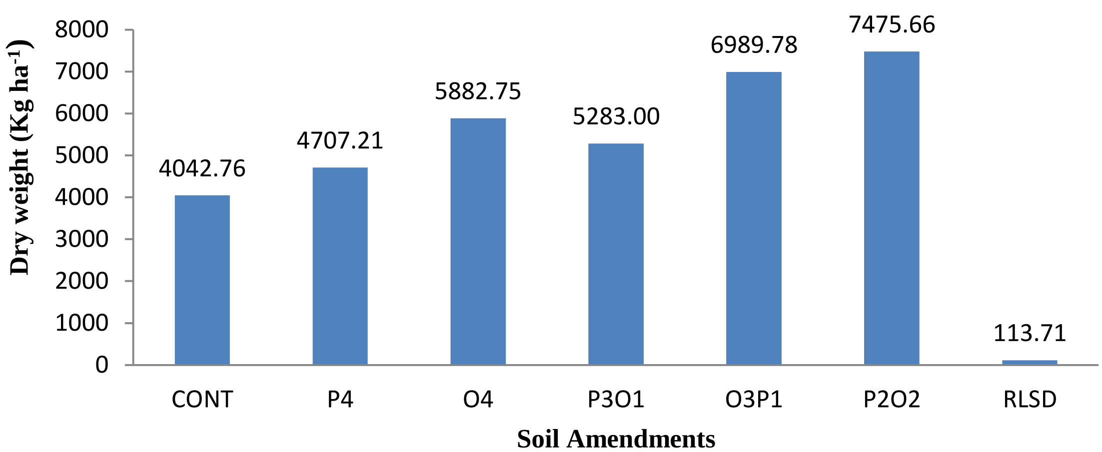

Figure (5) shows the effect of soil amendments on the plant's dry weight.

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